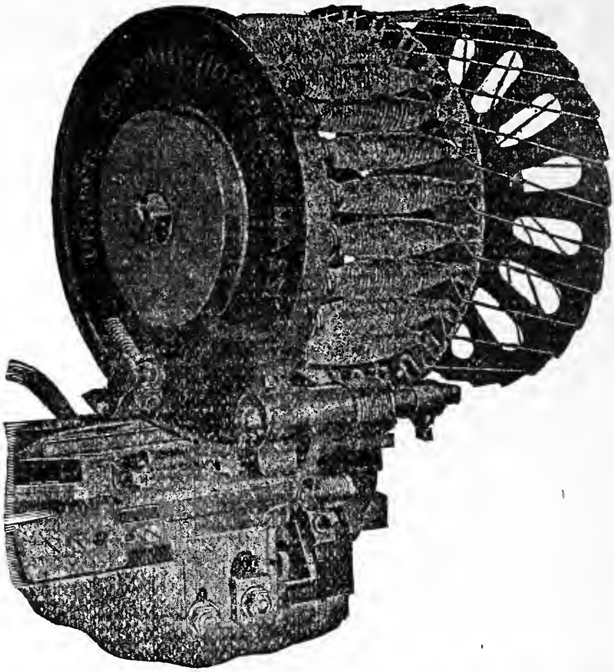

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CARDING AND SPINNING

A BOOK FOR PRACTICAL MILL MEN

BY

G. F. IVEY,

Author of "Loom Fixing and Weaving."

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PREFACE.

Several years ago I published a book called "Loom-Fixing and Weaving," which treated the subject in a thoroughly practical manner. This book has been very favorably received, and the second edition is now almost exhausted. From time to time I have received many inquiries for a book on carding and spinning, written on the same general lines, but no such book could be found. To fill this demand, the present work has been written, and if by simply being read it imparts information which has been acquired by many years experience, the object of the writer has been attained.

Believing that no one man possesses all of the knowledge available on the subject, I have had assistance from some of the best mill men in the country, among whom are Mr. Eben Willey, Allenton, R. I., and Mr. H. D. Martin, Fall River, Mass.

G. F. IVEY.

Hickory, N. C., July, 1904.

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Carding and Spinning.

CHAPTER I.

COTTON.

It is not the intention of the writer to discuss this question exhaustively, as it is not in the province of this book. "The Student's Cotton Spinner," by Nasmith, devotes over 80 pages to this subject, and the reader will find it treated in a very interesting and instructive manner.

There are nearly fifty varieties of cotton, but in the United States very little attention is paid to this fact. An increasing amount of Egyptian cotton is used in this country, principally for making fine hosiery yarn. It is also found that Egyptian is an excellent variety for mercerizing, and a good deal is used for this purpose.

American cotton is classed as follows, the first named being the best:

FAIR.

Strict middling fair.

MIDDLING FAIR.

Strict good middling.

GOOD MIDDLING.

Strict middling.

MIDDLING.

Strict low middling.

LOW MIDDLING.

Strict good ordinary.

GOOD ORDINARY.

Strict ordinary.

ORDINARY.

The grades in capital letters are known as full grades, and those with the prefix "Strict" as half-grades. Besides these, there are quarter grades known by the prefixes "Barely" and "Fairly." These quarter grades are very seldom used in classifying. Contrary to general belief, the grade is not affected by the length of staple. Both the length and staple are used in designating a particular kind of cotton, and we speak of inch and an eighth strict middling Mississippi cotton. Tinges and stains are terms frequently used in cotton reports, and usually belong under the lowest classification.

The grades mentioned above are for American cotton only, and for the United States only. The Liverpool Exchange has a different classification from this, and also a different one for Brazillian, Egyptian, or Indian cotton.

When cotton is spoken of in the cotton market, the Middling grade is meant, and the cotton contracts, or futures, call for this grade, although a better or a poorer grade may be delivered at a proportionate price. As a matter of fact, how-

ever, hardly one per cent of the cotton bought and sold on the New Orleans or New York Exchange is ever delivered. At or before the time of delivery the buyer or seller simply makes good the difference between the contract price and the price then current. In other words, the transactions are gambling pure and simply, and without doubt these transactions are largely responsible for the present inflated price of cotton (March, 1904). However, these contracts can be used for legitimate purposes. For instance, a mill man sells 100,000 or 500,000 pounds of yarn at a price he knows will bring him a fair profit at present price of cotton. He does not know, however, that cotton will remain at this figure, and to insure this profit, he must buy the cotton. Under any condition, and especially if cotton is 15 cents a pound, it would take an immense amount of money to buy the cotton, and a good deal to store and insure it. He can therefore purchase the cotton he needs for future delivery, paying only the nominal sum of $1.00 a bale. When the actual cotton is used it is generally bought at home, and the contract representing this cotton sold at New York. While this method is legitimate, and presents many advantages, there is no denying that the ease with which a contract may be bought and sold is a temptation for speculation, which not many can resist, and on the whole, the method does more harm than good.

Ginning.—Briefly stated, a modern cotton gin consists of a number of circular saws, from 60 to 90, about 10 inches in diameter, all on one shaft. These saws are about one-half inch apart, the space between them being filled by metal fingers. When the gin is in operation, the teeth of the saws, which are very fine, seize the fibers of cotton and carry the whole mass towards the fingers. These are too close to the saws to allow the seed to go through. The fibers are therefore torn from the seed, and are taken off the saws by a brush and blown to any convenient point. The cotton gin, except in matters of detail, is exactly what it was sixty years ago. If it had developed in the same proportion as other cotton machinery, the spinner would certainly have less cause to complain, for there is no doubt that the rough treatment cotton receives does the fibers great injury. Not only are they badly broken, but the shorter fibers are rolled in little balls, which it is almost impossible to get out, especially in long-staple cotton.

Egyptian cotton, and the best Sea Island, is not ginned with a saw gin, but with what is known as a knife, or roller gin. In this process the fibers are held firmly by rollers and revolving or oscillating knives scrape the seed away. This is an expensive method, but incomparably superior to the other.

CHAPTER II.

OPENING AND PICKING.

Strictly speaking, ginning is not considered a part of cotton manufacturing, although many mills in the South operate gins in connection with their mills. The first process which claims our attention is opening. In the United States this is generally done by hand. The bagging is removed from the bales, perhaps a dozen at one time, and the cotton is piled in successive layers until the whole has been distributed. Other bales are then opened and piled on top of the first. It is considered good practice to open as many as the space will allow, and to feed from the face of the pile rather than from the top, so as to get part of each bale. This practice is of much more importance in England than in this country, for here we are much more likely to get a large quantity of cotton from the same locality, and possessing practically the same characteristics; but even here there are advantages derived from this method. It has become the custom in recent mill construction to have the opening room in the cotton warehouse, and blow or rather suck the cotton to the mill building. This saves hauling the cotton to the mill, and has other advantages, especially for a large plant. For a small

mill, or one on fine numbers, and therefore using but little cotton, it is of no practical benefit, as it requires the attention of two men where only one is needed by the old method.

In England the common practice is to use a bale-breaker for opening the cotton. This is a machine with four sets of large rollers with very coarse flutes, or short spikes. The cotton in large armsfull is fed to this machine, and as there is a draft, of say two, between each set of rollers, it is thoroughly torn up by the time it gets through. There is now an improved bale-breaker on the market, manufactured both by Howard and Bullough, and Dobson and Barlow, known as the Hopper Bale-Breaker. It is similar to the older style, except that it has a hopper instead of a lattice. Two men can put half a bale of compressed cotton in the hopper at a time, and in less than five minutes it will be broken in fine flakes, and done much better than by hand. One of these machines can easily open 50 or 60 bales a day, and do it thoroughly. These machines will probably soon come into general use in the larger mills.

The cotton does not go direct from this machine to the hopper of the opener, but by an inclined lattice it is distributed on the mixing pile from which it is fed by hand.

Openers.—A great many mill men are not so young but that they remember when cotton was

fed entirely by hand. The lattice on which four laps are now placed, was marked off in sections of a yard each. A man would weigh a pound of cotton and distribute it as evenly as possible on this yard. While it was being fed he would weigh another pound, and so on indefinitely. For probably fifteen years the hopper feed has been almost universally used. It must not be taken for granted that because this machine is automatic, it will feed a uniform quantity regardless of the amount the hopper contains, and it is best to keep it from one-half to three-quarters full.

So far as the writer is aware, no American builder makes an opener with other than a horizontal beater. In England practically all openers have perpendicular beaters. These are known as Crighton openers, and have conical beaters, which revolve about 900 times a minute. The cotton is fed at the bottom, and is withdrawn at the top by a current of air in the usual manner. The only advantage, which in some cases may be considerable, which we see in this arrangement, is that as the beater is entirely surrounded by grids, the dirt will have a much better chance to be beaten through, than in the American machine where there is less than half the grid surface.

From the opener the cotton is sucked to the next machine, where it is formed into a lap. This may be done on the same machine, and as there

is an almost unlimited number of combinations of beaters, it is impossible to say exactly where the next machine begins. However, it is becoming more and more common to have the next machine—known as a lapper or picker, and in England as a scutcher—connected with the opener by a cleaning trunk. This may be 10 feet long, but in some cases it is 50. It is of great service if kept properly clean, but we see no especial benefit to be derived from the extreme lengths. It is customary to have three of these pickers, known as the breaker (a misleading term), intermediate and finisher. In some cases the intermediate is being omitted, and in all cases where extra long cotton is used, as the less this is beaten the fewer fibres are broken.

TROUBLES ABOUT THE PICKER ROOM.

Split Laps.—One cause of split laps, where the trouble only occurs occasionally, is too much waste in the mixing. This waste having been worked, has had the fibers all straightened out, and therefore there is not the same tendency to stick together as in raw cotton. Experience has taught us that where the mill is large enough to produce waste in sufficient quantity, it is best to run it separately and make laps of it. One of these waste laps is put on the apron of the intermediate, and the four laps run while this one is on the machine, containing one-fourth waste, are

laid aside, and only one at a time is used on the finishing lapper. The resultant laps have only one-sixteenth waste, or 6 per cent. By using this we know that the waste is evenly mixed, and we do not know it if it is put in the mixing haphazard. In many mills waste is never used in the mixing for warp yarn, but for the filling only.

Another cause of split laps is too much friction on the horse-head. This may occur on account of the weather, or the picker-hand may put soap or belt grease on the friction strap in order to make a nice, compact lap.

Probably the most fruitful cause of split laps is that the suction through both cages is equal, or nearly so. This causes the cotton to be matted in two sheets, with very little to hold them together. The remedy is simple. All modern lappers have dampers, so that the draft from each cage may be regulated. Arrange these so that the greater part of the draft is from the top cage, and the defect is generally overcome. Sometimes a careless operator allows the cages and air passages to become choked with waste or sand, and the draft not operating properly, trouble results. Occasionally the same trouble occurs by the air pipe leading from the fan becoming choked, and as they are often hard to get at, the trouble is consequently hard to discover and remedy. There is a certain patent arrangement by means of which tongues of leather or tin are

placed so as to almost feed into the bite of the cages. We fail to see, however, where the efficiency comes in.

Poor Help.—The troubles in many picker rooms are caused primarily by poor help. Many managers fail to realize the importance of this department, and think any green hand will do. In fact, it is usually considered the job for an unskilled man, and there are dozens of men throughout the country who apply for work, stating that they are picker-hands, who perhaps never worked a month in that department. On account of the isolated character of the work it is especially desirable to have a man in charge who can be relied on to tell the truth, and do what he is told to do without being watched. When a picker-man is told to weigh every lap and record the weight, also marking it on the end of the lap with colored chalk, many will do the recording all right, but will neglect the weighing.

Excessive Breakages.—As a breakdown in the picker-room often stops the whole mill, they should be especially guarded against. In this connection, what is said above in regard to poor help is especially applicable. Breakdowns are caused by insufficient oiling and cleaning, over feeding, allowing the machine to run too long after being choked, machines out of level, or improperly balanced beaters or fans. A very frequent cause of breakdowns is not watching the

gears closely enough, and allowing them to run without being in gear deep enough.

A beater which runs hot as the result of not being oiled, or from some unknown cause, can be frequently remedied by simply turning it end for end.

On the Atherton picker, the fast-running gear which runs the bottom cone frequently breaks or wears out, especially the intermediate gear. In an emergency a $1\frac{1}{2}$-inch belt will do the work until a new gear can be secured.

Excessive Waste.—This is caused by having the grid bars set improperly. If they are set too far apart, or too far from the beater, the waste will be excessive. There may also be too great a space between the feed roller and the first bar. In setting the grids, always bear in mind that a system of grids could be devised so that there would be no waste at all. Also remember that if they are set too near the beater the fibers will be injured. The air flues may be choked with waste, causing back pressure, or there may be an insufficient area in the flues or chimneys. In either case the back pressure will force the good cotton through the grids into the mote box.

Fires.—Of course any one who works about a mill knows that fire is more likely to occur in a picker-room than anywhere else about the mill. For this reason all kinds of precautions are taken to guard against it. It is generally in the opener

where the fire starts, but as it is directly connected with the next machine, it takes but a second to communicate to it. Where the pickers are in a separate room, the fire does little damage to them, although the opening room may be practically destroyed. The writer was once connected with a mill where fires occurred in the opener almost every day. The machine was carefully examined, and no hot bearings were found, neither was the feed roller too near the beater. It was finally noticed that occasionally sparks would be knocked through the grids. Although the beaters did not touch the rollers by three-eighths of an inch, they were separated still farther and the trouble was over. All this occurred a good many years ago, but a satisfactory explanation has never been given.

The chief trouble with fire is that if it does not get out of the machine, it melts the solder of the cages and chars and roughens the interior of the cleaning trunks. Often for hours, and perhaps for days, after the fire, the cotton is inclined to choke in the trunks. If they are not fire-proof, it is sometimes desirable to make them so by lining with tin, lapped as on fire doors. Where the wood is charred, about the best thing to do is to make a brush of card clothing and scour it out, afterward using powdered soap-stone or graphite freely. When a fire occurs, it is not best to stop the whole machine, but the feed only, and the

cotton is soon all burned out. If the machine is stopped, the screens are almost sure to be badly damaged. A chemical fire extinguisher is a valuable adjunct to a picker-room. A pipe for live steam with outside valve is more effective than many sprinklers, especially if the room can be tightly closed. This applies to the opening-room rather than to the picking-room proper.

In a mill where there is but one set of pickers, and the opener is put out of business several hours, or perhaps days, it is not necessary to stop the mill, for the cotton may be fed by hand to the next machine and the mill kept running.

Uneven Laps.—Years ago a lap which was within one pound of the required weight was considered near enough. Three years ago the requirements had become more strict, and laps that were over one-half pound out were run again. Now, in some mills, one-half pound is considered too wide a variation. If the machine is pushed for production, the light laps may be run at the same time as the heavy ones, and fairly satisfactory results obtained. The evening motion should be adjusted so that the belt is not in the center, but nearer the small end of the driving cone. It is probable that one lap on the apron may run out, but not at all probable that an extra one will be put on, and room should be allowed for the belt to shift enough to increase the speed of the feed mechanism in order to compensate for this loss.

Assuming that the evener is properly adjusted to begin with, the lack of attention in the way of cleaning and oiling will cause uneven laps sooner than any other cause. Pickers should be cleaned often, and the overseer should personally inspect them to see that it is done properly. The cages should be kept clean, or they will soon choke up around the ends. The apron must be kept at the proper tension, or it will sometimes slip and cause a thin place in the work. Another cause of uneven work is electricity. If it is present, it causes halts and dwells in the passage of the stock, and uneven laps are the result. The remedy is to have the room warm and sufficiently moist.

CALCULATIONS.

The only calculations about a picker are draft, speed and production. Even these are not often necessary, as the pickers are always set with a draft of about four, and there is very seldom any occasion to change it. We might give the calculations necessary to calculate the draft, but do not think the benefit derived would compensate for the space required. The speed, too, is a constant factor, and does not need changing unless the staple of cotton is changed, as long-stapled cotton should receive more gentle treatment than short.

A calculation is often given to show the length of laps. We do not give it here for the reason

that the calculated length is never the actual length. There is a slight draft between the calender rollers, and the pressure tends to stretch the lap and make it longer. This stretch is not a constant quantity, but varies with the weight of the lap. It may be said in general terms to be from 2 to 4 per cent. Laps are usually made about fifty yards long, but it is best to unroll one and measure its exact length. This must be known at least approximately, in order to get the weight per yard, and this is necessary in order to calculate what the weight of the card sliver will be. If, for instance, a lap is 48 yards long, and weighs 36 pounds, or $36 \times 16 = 576$ ounces, one yard will weigh $576 \div 48 = 12$, and the lap is known as a 12-ounce lap.

When the laps are light it is desirable to have them longer than 50 yards, and by increasing the size of the knock-off gear, or decreasing that of its driver, this may be readily done. If the knock-off gear has 40 teeth, and the lap weighs 36 pounds, by changing the gear to 50 teeth, the lap will be one-fourth longer and weigh 45 pounds, but still be the same weight per yard. The machine will then run longer without doffing, and the laps will also run longer on the cards. Thus the production of the picker is increased, and to a certain extent that of the cards also, with less attention by the operative. Of course long laps are desirable under any condition, but if they

weigh over 45 or 50 pounds, they are too heavy to handle conveniently.

Production.—The calculation for production is a very simple matter. We simply note how long it takes to make a lap, and the number of minutes divided into 60, and this quotient multiplied by the number of hours in a day's work will give the total number of laps that can be made. This multiplied by the weight per lap gives the production per day in pounds. Suppose a lap, weighing 33 pounds, can be made and doffed in 12 minutes. Then $60 \div 12 = 5$, and $5 \times 11 = 55$ laps per day. As a lap weighs 33 pounds, the daily production will be $55 \times 33 = 1{,}815$ pounds. If more production is wanted, and it is not practicable to increase the weight of the lap, it is an easy matter to increase the speed of the feed by using a larger pulley. For coarse yarns, one set of pickers should easily produce 15,000 pounds per week. The finer the yarn, the lighter the lap should be, and the smaller the production.

GENERAL INFORMATION.

When mill building is active, the builders of cotton machinery form a kind of combine to maintain prices. When there is but little building going on, there seems to be an understanding that these prices may be reduced. At present (March, 1904) the combination prices are as follows:

Self-feeder connected with opener..	$600.00
One-beater picker	750.00
Two-beater picker	1,100.00
Automatic cleaning trunk, per ft.,	10.00
Thread extractor	150.00

All these machines are about six feet wide, and a full set may be put across a 75-foot mill. If there are two sets, the room should be 24 feet, or 3 bays wide; if there is but one set, and no probability of ever being more, 16 feet, or 2 bays, are sufficient.

Pickers built in America are shipped to the mill set up in sections, weighing several thousand pounds each. If they are English machines, they are of course knocked down. These sections are assembled by a skilled machinist sent from the shop. By the terms at present in use, the mill pays for his time at the rate of $4.00 per day while he is at the mill, the machine builders paying his board and traveling expenses. The mill also furnishes him with common labor and the services of a carpenter. This rule also applies to other machines throughout the mill. Machines are not sold in the New England States on this basis, but are generally erected on the mill floors for so much, the shop paying all expenses. We have recently heard of one mill in the South which was equipped on this basis, but only one. The mill also pays the freight, which

is practically the same from all New England shops, and to most points in the South is 50 cents per hundred pounds. A set of pickers, with automatic feeder connected with opener, and three one-beater pickers, will weigh, with boxing, about 30,000 pounds, and will cost about $3,000.00. In this case the freight is $150.00, or 5 per cent of the cost. In general terms, the cost of freight and erection is estimated at 10 per cent of the total cost.

CHAPTER III.

CARDING, DRAWING AND COMBING.

It is the opinion of the writer, and we think of all intelligent mill men also, that carding is the most important process in the mill. If it is well done, good yarn can be produced. If it is poorly done, no amount of care in subsequent processes can make the damage good. We have in mind one of the most successful mill men in the country, who when building his first mill, put in nearly double the number of cards which was considered necessary. Even the machine builders told him that it was an unnecessary outlay, but he persisted, and to-day he is president of a half dozen mills. Where coarse yarns are made, good carding is not absolutely necessary, but it is very desirable; but where fine yarn is made, it is absolutely necessary to have plenty of cards, and to card light.

There are still a great many top-flat cards in the country, but as they wear out they are being thrown out, and none are being built. There never were many roller cards used in this country, but in England they are quite popular, but are rapidly being superceded by the revolving flat. These roller cards are still used where a large production is wanted, without any special regard to its quality. They are therefore used throughout England and Europe for very coarse

yarns, and are exclusively used where waste is re-worked. For batting works, they are used for carding sweepings, flyings, etc., and are capable of an enormous production. Waste yarns, in the true sense of the word, are seldom made in the United States, or even in England, but principally in Germany and Italy. The coiler is not used, but the web is separated by rings on a kind of front roller, and is compressed into a form of roving, which is spun on a special mule, similar to a woolen jack. The carding process is generally repeated.

We will not discuss carding at length, as this book is not intended for beginners, but for men who are supposed to know the fundamental principles of cotton manufacturing. The card is by far the most delicate machine in the mill, and requires the most attention. The card grinder must be a skillful man, and not have more to do than he can do well. It requires considerable skill to grind a card properly, but a great deal more to adjust the various parts. The flats and doffer must be set close to the cylinder. If the flats are too far off, the cotton has a tendency to roll up in little balls called neps. These neps are also formed in the gin, and it is the function of the flats to remove them instead of making more. If the card needs stripping, these neps can be seen in the web, showing that the spaces between the teeth are as full as they can hold.

Card Setting.—Different carders have different ideas about the exact setting of a card, but all agree that the doffer and flats should be as close as possible without rubbing. This depends a good deal upon the stability of the floor, and to a less extent on the make of the machine. The following table will usually give good results:

Comb	.012
Doffer	.005
Flats	.009
Licker-in	.009
Mote-knives	.012
Casing	.012

TROUBLES ABOUT A CARD.

The principle trouble will always be to get the web uniform and free from the impurities. If a fleece can be held up before the light, and be free from this trouble, the carding may be said to be perfect. As is said above, this may be attained by careful grinding and setting. There are all kinds of ideas about how often a card should be ground. A general answer might be, when they need it. This will apply to almost any machine except the card, which should *never* need it. In other words, it should always be ground a little before it needs it. After a card is in good fix, it should be ground lightly once in two or three weeks. We are aware that cards are often run

as many months, and one case is on record where they ran for over a year, but for the best results they should receive frequent attention.

Rubbing.—Occasionally a cylinder will begin to rub against the casing or arches. This is almost always caused by the card not being level. By a judicious use of shingles and a spirit level the trouble can almost always be stopped. It is occasionally caused by one end of the shaft wearing and letting that end lower than the other, even when the frame may be level. The remedy is obvious.

Cloudy, or Uneven Carding.—The cotton may be well carded so far as the removal of impurities is concerned, and still be cloudy or uneven. This may be caused by split or uneven laps, dull clothing, or clothing which has been mashed in places; also by uneven setting of the doffer or flats, that is, set further from the cylinder at one end than at the other. Another point that is often unnoticed, because it does not affect the appearance of the web, is the top calender roll. On some cards it is turned by contact, and can easily be made to turn sluggishly by being choked with waste. Cans running too full also strain the sliver.

Electricity.—At times this practically stops the card-room, especially with some kinds of colored cotton. A few years ago this trouble was much more prevalent than now. There are some dye

stuffs which are cheaper than others, and can be used in summer time with economy, but the good dyer now knows where to look for trouble and guards against it. In recent years, nearly all mills are provided with a system of artificially moistening the air, and it is a well-known fact that moist air conducts electricity to the pipes, and thence to the ground. Where there is no air-moistening system, a very effective remedy is to let live steam into the room. If this is impracticable, simply sprinkling the floor will generally help matters. A good deal of trouble in this line will be avoided by insisting that the room be comfortably warm early in the morning. The writer has known of cases where about everything was tried, and the closing of the door to the picker-room had the desired effect.

Fires.—Every precaution should be taken to prevent fires, but with all possible care they will sometimes occur. If the lap gets on fire, remove it and let the machine run until the cotton is all out. If by the zeal of some operative a large quantity of water is thrown on the card, all the casing should be removed from around the cylinder, and the machine run at full speed until dry. The centrifugal force will throw the water from the cylinder, and the air currents will soon cause the water to evaporate. A small quantity of water thrown on a card, if quickly removed, does but little or no damage.

In case there is fire in the room above, and water is likely to get on the cards, they should be immediately covered. If nothing else is convenient, laps are always at hand and can be unrolled so as to cover the entire cards several times.

CALCULATIONS.

There are only two calculations of any importance about a card—draft and production. Under ordinary conditions, the draft should be between 75 and 100. On the roller card it is frequently 125. To find the draft, consider the feed roller the driver. Then multiply the diameter of the delivery roller (in the coiler) by all the teeth in the driving gear, and divide this by the diameter of the feed roller, multiplied by all the driven gears. The quotient will be the draft. We might add here that this rule will apply to any machine where the draft is desired. To be more explicit, multiply the diameter of the small calender roll by the feed roller bevel gear, the large bevel gear on the side shaft, the large gear on the doffer (always neglect intermediate gears, which only transmit motion, but have no effect on speed), gear on calender roll which drives upright shaft, and gear on top of upright shaft for a dividend. Then multiply the diameter of feed roller by small gear on side shaft (draft gear), small gear on doffer, gear on calendar roll (near big doffer gear), bottom gear on upright shaft, and bevel

gear on small calender roller for a divisor. The quotient will be the draft required. Taking, for an example, a Mason card, the figures would be thus:

$$\frac{1\frac{11}{16}\times130\times34\times212\times29\times24}{2\frac{7}{16}\times21\times34\times28\times15\times18}=83.64$$

If this calculation were made without the draft gear 21, the quotient would be 1756.57, which is the draft constant. This divided by the draft gear will give the draft, or divided by the draft will give the draft gear.

In this card the bevel gear on doffer end of side shaft is the same size as the one on doffer shaft, and both may be left out of the calculation. In other makes of cards, the bevel gear on top of upright shaft is the same as the one on coiler calender roll, and may be omitted.

Another, and a much quicker way to calculate drafts, is to take the weight of a yard of lap in grains and divide by the weight of a yard of sliver in grains. There are $437\frac{1}{2}$ grains in an ounce, and in a 12-ounce lap there are 5,250 grains. If the sliver weighs 60 grains, the draft is 5,250 ÷ 60, which is $87\frac{1}{2}$. There is of course a slight loss on account of waste, but this method is near enough for all practical purposes.

The term "Constant," which is here used, and which will be frequently used throughout this book, means a definite ratio between the gear and

the quantity the gear is intended to control. It is almost always the product of the quantity and the number of teeth in the gear. This is always the case when the gear is a driver, but not always when it is a driven gear. In the following tables it is the draft multiplied by the draft gear, therefore if the constant is divided by the draft gear we get the draft, and *vice versa*. By the use of the constant, the overseer can quickly figure a set of changes which will cover all possible demands.

TABLE OF GRAINS IN ONE YARD OF PICKER LAP.

1 ounce = 437½ grains.
1 pound = 7000 grains.

Ounces.	Grains.	Ounces.	Grains.	Ounces.	Grains.
1	437.5	8	3500	13	5687.5
2	875	9	3937.5	13½	5906.25
3	1312.5	10	4375	14	6125
4	1750	11	4812.5	14½	6343.75
5	2187.5	11½	5031.25	15	6562.5
6	2625	12	5250	15½	6781.25
7	3062.5	12½	5468.75	16	7000

TABLE OF DRAFT CONSTANTS, 24¾″ DOFFER.

Make of Card.	Compensating Gear.	Callender Gear.	Constant.
Mason			1574.35
Whitin	38		2198
Whitin	39		2141.80
Whitin	40		2088.20
Lowell		28	1605.5
Lowell		29	1550.8
Pettee			1534.6

TABLE OF DRAFT CONSTANTS, 27¾" DOFFER.

Make of Card.	Compensating Gear.	Plate Gear.	Bevel on Doffer.	Bevel on Side Shaft.	Constant.
Mason					1756.40
Whitin	38				2373.80
Whitin	38				2313
Whitin	40				2255.26
Pettee					1534.60
Howard &		120	mitre.	mitre.	1600
Bullough		120	24	34	2300
(26¾")		170	24	34	3200
	Callender Gear.				
Lowell	20				1667.25
Lowell	21				1587.86

Constant ÷ Draft = Draft Gear.
Constant ÷ Draft Gear = Draft.

By the use of this table the overseer can quickly figure a set of changes for any particular card. For instance, take the first constant in the table, 1574.35. This divided by a 13 tooth gear gives a draft of 121.10, by 14, 112.45, by 20, 78.71, etc.

PRODUCTION.

Rule.—*Multiply the circumference (diameter multiplied by 3.1416) of the doffer in inches by the number of turns per minute, the number of minutes in an hour, the number of hours in a day, and the number of grains in a yard. Divide this product by 7000 (grains in a pound), and by 36 (inches in a yard). The quotient will be the theoretical production.*

Example: If the card sliver weighs 65 grains, and a 24-inch doffer makes 12 revolutions per minute, what is the production in 11 hours?

$$\frac{24 \times 3.1416 \times 12 \times 60 \times 11 \times 65:}{7000 \times 36}$$

This works out 154, which is the number of pounds per day, from which 5 per cent should be deducted for necessary stops.

A quicker way to get the production is to notice how long a lap of a certain weight lasts, and then calculate the number of pounds.

Example: If a 35-pound lap lasts 2 hours, what is the production for 11 hours? It will be seen at a glance that it would take $5\frac{1}{2}$ laps a day, and $5\frac{1}{2} \times 30 = 165$ pounds.

PRODUCTION TABLE FOR CARDS FOR 10 HOURS, 27¾″ DOFFER.

Revolutions Per Minute.	Number of Grains in One Yard of Sliver.								
	40	45	50	55	60	65	70	75	80
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs	Lbs.	Lbs.	Lbs.	Lbs
8	64	72	80	88	96	104	112	120	128
8.50	68	76	85	93	102	110	119	127	136
9	72	81	90	99	108	117	126	135	144
9.50	76	85	95	104	114	123	133	142	152
10	80	90	100	110	120	130	140	150	160
10.50	84	94	105	115	126	136	147	157	168
11	88	99	110	121	132	143	154	165	176
11.50	92	103	115	126	138	149	161	172	184
12	96	108	120	132	144	156	168	180	192
12.50	100	112	125	137	150	162	175	187	200
13	104	117	130	143	156	169	182	195	208
13.50	108	121	135	148	162	175	189	202	216
14	112	126	140	154	168	182	196	210	224
14.50	116	130	145	159	174	188	203	217	232
15	119	135	150	165	180	195	210	225	240
15.50	124	139	155	170	186	201	217	232	248
16	128	144	160	176	192	208	224	240	256
16.50	132	149	165	181	198	214	231	247	264
17	136	153	170	187	204	221	238	255	272

NOTE—If the Doffer is 24¾″, the production will be 10 per cent less than above.

GENERAL INFORMATION.

The combination price of a 40-inch card (some are built 45 inches) is $650.00. At the present time we have heard of them being sold as low as $450.00. Grinding rollers, strippers, etc., are charged extra, and cost $214.00 a set, a set being enough for about 25 cards.

It must not be supposed that all cotton machinery is built in England and America. There is a great deal built in France and other European countries. The Alsatian Construction Company, besides building a well-known comber, manufactures a card where the flats run backward to the usual direction. This, of course, necessitates the flats being stripped from the rear. It is claimed for this method that the dirty flats strike the cotton first, and the carding process is finished by flats which have just been stripped, and are therefore in a condition to do the most good.

It was formerly the custom to card the cotton twice, where extra good yarn was required. The writer knows of a good many mills where this is still done. It is probable, however, that one modern card can do better work than two of the old style. In carding waste, it is still the practice to card double, and from the character of the material, such practice is necessary.

In most of the large mills it is customary to use the card strips for making coarse yarn, a fair proportion of good cotton being mixed with the waste. A card has recently been brought out which runs the strips into a sliver, and coils it into a can. This may then be run through the drawing frame in any proportion desired. By this method, re-picking and re-carding the material is dispensed with, also a considerable amount of extra trouble in other particulars.

DRAWING FRAMES.

The object of a drawing frame is two-fold. First, to draw out several slivers into one, and thus reduce any unevenness which may exist in any one sliver; second, to lay the fibers approximately parallel. The latter operation is the more important, and is accomplished by four rows of fluted rollers, each succeeding roller running a little faster than the preceding one. The draft is generally equal to the doubling, and the almost universal custom now is to double six slivers into one, and by drawing six, to make the delivered sliver the same weight as the original. Occasionally it is desirable to increase or decrease the weight of sliver at the drawing. This can readily be done either by changing the draft, or the number of ends. Carders have become so accustomed to seeing a draft of six, and six ends

up, that they are inclined to think that any other combination would not produce good work. They forget that the drawing frame of twenty years ago usually had only three ends up, and a draft anywhere from three to eight.

Drawing frames are the simplest machines in the mill, and for that reason their importance is often overlooked. The most inexperienced labor operates them, and the consequences are frequently disastrous. If one end breaks on the finishing drawing, the resultant sliver is one-sixth too light. This irregularity runs in a constantly decreasing degree, but increasing length, all through the mill, and many an end on the spinning frame and loom comes down from no other cause.

The metallic roller has now been on the market for a good many years, and is increasing in favor. It certainly gives a constant draft, and on heavy work this is attained with the ordinary roller only by heavy weighting. The metallic roller also stops a great many roller laps, saves cost of covering rollers, and gives a larger production per frame.

The top clearers for the rollers receive more attention in England than they do in America. As a rule, they are of one style here, namely, flannel bands, resting on the rollers, the accumulating waste being removed from time to time by the attendant. Another method used in England

is to place felt-covered rollers on top of the leather rollers, one between the first and second, and one between the third and fourth. These revolve as the frame runs, and take up all the loose fibers. Another method which is largely used where long cotton is necessary, is a broad band of flannel which slowly revolves over the rollers and collects the waste, which is removed either by hand or with a comb.

Twelve or fifteen years ago the electric stop motion was very popular, and many are still being used. However, they are so likely to get out of fix, and as one defect often interferes with a good many machines, they are becoming less frequently ordered. All things considered, the mechanical stop motion is probably the more satisfactory.

Setting the Rollers.—This is a subject on which a great deal of misinformation has been given. We have seen this rule printed a dozen times: "Set the centers of first and second rollers one-eighth inch further apart than the length of staple," etc. Some authorities even say 1-16 inch. The front rollers are usually $1\frac{3}{8}$ inches in diameter, and the others $1\frac{1}{8}$ inches, so if the two rollers were actually touching, their centers would still be $1\frac{1}{4}$ inches apart. How, then, could the rule apply to $\frac{7}{8}$-inch cotton?

A much better rule is to set the *bite* of the rollers $\frac{1}{8}$ inch further apart than the length of the

staple for the first and second line, and increase the difference $\frac{1}{8}$ inch for each succeeding set. Theoretically, two cylindrical bodies, regardless of their diameter, touch one another at only one point, but we must bear in mind that the top roller, if leather, has a flattened surface at the point of contact, and the bite extends at least 1-16 inch on each side. If the top roller is metallic, the bite is still further from the center on account of the meshing together of the flutes. The above rule will apply under ordinary conditions, but many cases arise where it is desirable to change this setting. Besides the length of staple, the setting depends on the thickness of the sliver, the speed of the machine, and the amount of draft. If the length of staple were the only consideration, the back rollers would be set the same as the front.

TROUBLES ABOUT DRAWING FRAMES.

Irregular or Cut Drawing.—The causes of this are many, but probably one of the most frequent is lack of oil. This may not be the immediate, but the remote cause. We have known drawing frames run for many years with irregular oiling until the saddles had worn to an exact fit on the rollers. The least little wrench to one side or another would cause the saddles to bind, and momentarily stop or retard the roller. Where shell rollers are used (and they are much better),

lack of oil is much more common, and the overseer should have the arbors removed every Saturday evening, and stay out until Monday, when they are oiled and replaced. The trouble consequent on cut-roll drawing is much too serious to omit any precaution for preventing it.

Cut drawing may result from bad rollers, either because they are improperly covered, or because they need varnishing. The varnishing should be done frequently, and it must not be assumed that the operative in charge is a competent judge as to when rollers should be replaced. Almost every overseer has receipts for making varnish, some of which are good, and some bad. The following is used in the largest mill in Massachusetts, and is a good one:

Acetic acid	1 qt.
Glue	8 oz.
Gum Arabic	4 oz.
Oil of Origanum	2 spoonsful.
Chrome Green	As needed.

Vinegar is not as good as acetic acid, but will do. Green or blue is a better color than red or yellow, as it is in greater contrast with the color of the leather, and thin places can be more quickly detected. The oil of origanum is used to make the varish dry quickly. Any volatile oil will do, as oil of cloves or oil of peppermint.

Cut drawing may be caused by too great a draft between the front roller and the calender roller. This should be just enough to keep the sliver from bagging, and just a little bagging is better than the opposite extreme. If this trouble is suspected, stop the frame, press the sliver by hand until it bags, then start it. If the slack is taken up quickly, it is evidence of too much draft. The trouble is often occasioned by damp weather. All mill men know that during damp weather the work becomes heavy. A great many assume that this is because of the additional weight of water absorbed. This, however, is responsible for only part of it. When the fibres get the least damp, they have a tendency to stick together, and become harder to draw. The draft is thus reduced a little at every process, and consequently the work becomes heavy. At the drawing frame, the trouble is aggravated on account of the cotton having to be drawn through the small hole in the trumpet. This makes the drawing bag between the front and calender roller, and the carder will change the draft a little. When the atmosphere becomes dry, he will probably forget about it, and the consequence will be an injurious draft.

Where metallic rollers are used, a very small piece of leaf, seed or piece of broom-straw, getting wedged into one of the flutes will cause cut work. It is absolutely necessary to keep the roll-

ers clean, and each operative should be provided with a stiff brush for that purpose.

Another cause for cut or strained drawing, is filling the cans too full; when they are so full that there is decided friction against the coiler, strained work is sure to result. This is also true at the card. Excessive speed, causing top rollers to jump, or a bad arrangement of back cans, causing the sliver to be strained before reaching the frame, will also cause uneven work. An excellent way to test the quality of drawing, is to take a few feet and tightly twist it. If it twists evenly, it is uniform. If it is not uniform, the twist will run into thin places, and can readily be detected by the eye, or by running it through the fingers.

Electricity.—As in the card, this will give a great deal of trouble at times, and the same remedies will apply. The writer had one case where all remedies failed. In this particular mill, the sliver would stick to the cans, and become so tangled that it was impossible to use it. Tin cans would probably have stopped the trouble, but that was impracticable. As a last resort, a half-inch steam pipe was run under the coilers just back of the cans. This helped matters a great deal, but the trouble was never entirely eliminated.

CALCULATIONS.

The calculations on a drawing frame are for production and draft. For getting the production, we multiply the circumference (diameter multiplied by 3.1416) by the speed per minute, the minutes in an hour, the hours in a day, and the weight of a yard of sliver. This is divided by 36 (inches in a yard) × 7000 (grains per pound). The quotient is the theoretical production, from which 10 per cent should be deducted for necessary stops. This is the production for one delivery, and must be multiplied by the number of deliveries to get the total production.

Example.—If the front roller is making 325 revolutions per minute, the sliver weighs 60 grains, and the front roller is $1\frac{3}{8}$ (1.375) inches in diameter, what is the production in 11 hours?

$$\frac{1.375 \times 3.1416 \times 325 \times 60 \times 11 \times 60}{36 \times 7000.}$$

This works out 220, and 220 less ten per cent is 198.

PRODUCTION TABLE DRAWING FRAMES, 10 HOURS.
FRONT ROLLER 1⅜ INCHES.

Revolutions Per Minute.	Number of Grains in One Yard of Sliver.								
	40	45	50	55	60	65	70	75	80
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs
250	93	104	116	127	139	150	162	174	186
260	96	108	120	132	144	156	168	180	192
270	100	112	125	137	150	162	175	187	199
280	104	117	130	143	155	168	181	194	207
290	107	121	134	148	161	174	188	201	214
300	111	125	139	153	167	180	194	208	222
310	115	129	143	158	172	186	201	215	229
320	118	133	148	163	178	192	207	222	237
330	122	137	153	168	183	198	214	229	244
340	126	142	157	173	188	205	220	236	252
350	130	146	162	178	194	211	227	243	259
360	133	150	167	183	200	217	233	250	266
370	137	154	171	188	205	223	240	257	274
380	141	158	176	193	211	229	246	264	281
390	144	162	180	197	217	235	253	271	288
400	148	167	185	204	222	241	259	278	296
410	152	171	190	209	227	247	266	285	303
420	155	175	194	214	233	253	272	292	310
430	159	179	199	219	239	259	279	298	318
440	163	183	204	224	244	265	285	305	325
450	167	187	208	229	250	271	292	312	333

10 per cent has been deducted for stops.

The above table is for frames with leather-covered rollers. If metallic rollers are used, the production will be from 15 to 25 per cent greater, depending on the weight of the sliver. The lighter the sliver, the greater will be the difference.

Draft.—The rule for calculating the draft of a drawing frame is the same as for cards, viz., consider the back roller the driver; multiply the

diameter of the delivery roller (calender) and all the driving gears, and divide the product by the product of the diameter of the receiving roller (back roller), and all the driven gears. As we went into this somewhat fully in reference to the cards, we will not go into the calculations in detail.

The draft of a drawing frame is in four places; between the back and third roller, the third and second, the second and first, or front, and between the front and calender. The total draft is the product of these, and not the sum, as many erroneously suppose. It is customary to have the greater part of the draft between the front and second rollers. The reason for this is that where, say six slivers enter the back of the machine, they form a thick strand. If much draft were wanted here, it would not only require very heavy weights on the rollers, and a great deal of power to turn them, but the draft would probably be irregular. For this reason a very slight draft is used, about 1.25; between the next two rollers, the strand is not so heavy, and may be more easily drawn. The draft here is, say, 1.35. Between the next two rollers a maximum draft is used, generally between 3 and 4, say 3.50. From the front to the calender roller is a very slight draft of about 1.03. Taking these figures, and multiplying them, we find the total draft to be $1.25 \times 1.35 \times 3.50 \times 1.03 = 6.07$.

TABLE OF DRAFT CONSTANTS FOR DRAWING FRAME.

Make of Frame.	Back Roller Gear.	Compensating Gear.	Second Roller Gear.	Constant Leather.	Constant Metallic.
Mason	24	....	....	123	132.80
Mason	48	....	....	246	265.60
Whitin	....	69	....	209.70	185.6
Whitin	....	70	....	212.70	188.1
Whitin	....	71	....	215.70	191.1
Pettee	40	....	....	172.50	172.5
Pettee	60	....	....	258.60	258.6
		Carrier			
Howard &	....	Gear	34	11.75	....
Bullough	....	Driving	36	11.74	....
"	....	2d Roller	38	11.73	....
"	....	28	30	....	10.77
"	....	28	31	....	10.78
"	....	28	32	....	10.76
	....	26	32	....	10.77
	Crown Gear.				
Lowell	25	....	....	6.83	5.73
Lowell	35	....	....	9.60	8.10

For H. & B. and Lowell Constant × Draft = Draft Gear.
For other makes Constant ÷ Draft = Draft Gear.

It will be noticed that the drafts for metallic rollers are about 10 per cent greater than for leather covered. The reason for this is that when the slivers first enter the machine, there is a thick strand, and the flutes can not mash the fibers down into the corresponding depressions. As the sliver is drawn towards the front roller, it becomes thinner, and each succeeding set of rollers mash it deeper into the depressions, thus elongating it and making more draft. It can be

readily seen that the lighter the drawing is, the more this mashing process will be from the start, and therefore the less the difference would be. If a single light sliver were run through, there would be very little or no difference in the draft on account of metallic rollers. The makers of the metallic rollers figure the amount of sliver delivered at 1 1-3 times the actual circumference of the rollers, on account of the fluting effect. This is about the correct ratio for the front roller, and for calculating production, but it will not do for drafts, because the back roller has practically no fluting effect.

GENERAL INFORMATION.

The combination price of a drawing frame with 6 deliveries is $60.00 per delivery. With metallic rollers, the price is $15.00 additional. A 6-delivery frame will occupy with cans a space of 11 feet by 4½. Three frames will readily go across a 25-foot bay if set lengthway with the mill; if set across, about 12 deliveries can be put into a bay, leaving room to pass around each end. With boxing, drawing frames weigh about 450 pounds per delivery. They are now usually made so that, if desired, the can-tables are put on top of the floor, instead of being sunk in as formerly. This is a more sensible arrangement for several reasons.

One operative can attend to about eighteen deliveries on ordinary work. If the work be fine, the cans will empty and fill much more slowly, and more work can be done. In a rough way it may be said that one delivery of drawing (for each process) will be required for each card.

Within the past few years, it has become a custom in a good many mills to use only two processes of drawings for numbers under 30's. The writer has made very careful experiments in this line on 24's, carefully testing many bobbins on each system. The result showed that the yarn from the three-process work was the stronger by from 3 to 5 per cent. We know of similar tests having been made with the same results, and also know of opposite results having been reported. The theory is certainly in favor of three-processes, except in very coarse work where the loss of strength does not amount to much.

As in other machines, 3 draft gears are sent with each machine, and if there are change gears for the calender rollers (as there should be), 3 of these are also sent. If leather-covered rollers are used, 10 per cent extra ones are sent. If the mill is small, say with only 18 deliveries of drawing, there will be a total of 72 top rollers. Ten per cent of this is only 7, which is not a sufficient number. Where there are a good many deliveries, 10 per cent spare rollers is ample.

SLIVER-LAP MACHINES AND RIBBON-LAP MACHINES.

Where the work is not very fine, the card sliver is first run through one process of drawing, then through the sliver-lap machine, from which it goes directly to the comber. For finer yarns, or where better work is desired, the sliver goes direct from the cards to the sliver-lap machine, from which it is taken to the ribbon-lap machine before going to the comber. This is much the better system, for it is impossible to get a lap from the sliver-lap machine perfectly even across it, although it may be even lengthways. As it is formed of slivers, there is first a thick place, and then a thin one all the way across. If the shorter process is used, the lap is made $8\frac{1}{2}$ or $8\frac{3}{4}$ inches wide or sometimes wider, depending on the width of the comber. If the double process is used, the lap is 1 inch narrower, to allow for expansion in the ribbon machine. In the sliver-lap machine, from 12 to 24 slivers are run through 4 sets of rollers similar to a drawing frame, only a slight draft being used. This web is run between heavy calender rollers and wound as a lap. There is a stop motion for each sliver at the back, and also one to stop the machine when the lap is of a certain length.

The ribbon-lap machine is similar to the sliver-lap machine, except that 6 sliver laps are fed, and there is a draft of 6. The 6 laps are not put

together until after they are drawn, as it would be impracticable to draw such a thick strand. The drawn webs are very thin and delicate to handle. After leaving the rollers, they are turned at right angle over a highly polished plate, and are run one over the other, until all are collected together and condensed into the form of a lap ready for the comber. These angle plates in damp or cold weather often give a great deal of trouble. A recent improvement has all the webs delivered from the rollers in the same direction in which they are to be calendered, and the angle plates dispensed with.

CALCULATIONS.

The calculations on these machines are so simple, and there being so little necessity for changing, we will not take space to explain in detail, but give tables below which may be found useful.

PRODUCTION TABLE, SLIVER-LAP MACHINE, 10 HOURS.

Rev. Per Min. of 5″ Cal. Roll.	Grains Per Yard of Lap Produced.										
	200	210	220	230	240	250	260	270	280	290	300
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs
50	337	354	370	387	404	421	438	455	471	488	505
55	370	389	407	426	444	463	481	500	519	537	556
60	404	424	444	468	485	505	525	545	566	586	606
65	438	460	481	503	525	547	569	591	613	635	657
70	471	495	518	542	566	589	613	636	660	683	707
75	504	531	555	581	606	631	656	681	707	732	759
80	539	566	593	620	646	673	700	727	754	781	808
85	572	600	630	651	686	715	744	772	801	829	858
90	606	634	667	697	727	758	788	818	848	878	909
95	640	670	704	736	767	800	831	863	895	927	959
100	673	707	741	775	808	842	875	909	943	977	1010

10 per cent is allowed for stops.

For approximate calculation, the production may be considered to be 500 pounds per day.

DRAFT TABLE, SLIVER-LAP MACHINE.

Mason.			Whitin.		
Gear.	Draft.	Constant.	Gear.	Draft.	Constant.
33	1.50	22	20	3.22	64.4
34	1.54	22	21	3.07	64.4
etc.	etc.		etc.	etc.	

Mason Frame, Constant $\times$ Draft $=$ Gear.

Whitin Frame, Constant $\div$ Draft $=$ Gear.

PRODUCTION TABLE. RIBBON-LAP MACHINE, 10 HOURS.

Rev. Per Min. Cal. Rolls.	Grains Per Yard of Lap Produced.										
	200	210	220	230	240	250	260	270	280	290	300
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
90	606	636	666	697	727	757	788	818	848	879	909
95	640	672	703	735	767	799	831	863	897	927	959
100	673	708	741	774	808	841	875	909	942	996	1010
105	707	742	777	813	848	883	919	954	990	1025	1060
110	741	778	815	852	889	926	963	1000	1037	1074	1111

10 per cent is allowed for stops.

GENERAL INFORMATION.

A sliver-lap machine, including cans, occupies the space of 9′ × 4′-4″, and weighs about 1,500 pounds. They cost $400.00, and one operative can attend to about eight machines, or to a less number and other work in addition. As these machines are only used in fine mills, where the production is small, there are seldom more than 3 or 4 machines. One machine will produce enough for 5,000 spindles on number 60's. It will then be seen that so far as labor is concerned, it adds very little to the cost of production. What makes combed work cost so much is the large per cent of waste which the comber takes out. This, however, will be discussed later on.

A ribbon-lap machine with 6 doublings occupies the space of about 14′ x 4′-6″, and weighs from 3,000 to 4,000 pounds. The list price is $1,000.00, and like the sliver-lap machine, it requires but little attendance.

COMBERS.

Contrary to general belief, the comber is not a modern machine, but was invented over fifty years ago by a Mr. Heilmann, who received $150,000 for its use in England. The comber practically selects the long fibers from the short ones, and yarn spun from combed stock is not only much smoother, but also much stronger than if made from carded stock. In operation, a pair of rollers deliver about one-quarter of an inch of lap to the nippers. The rollers then stop, the nippers close and hold the lap while several rows, usually seventeen, of very fine needles pass through the projecting fibers and remove the shorter ones, also taking out any nep or leaf that may be present. The nippers then open, the fluted segment pulls the long fibers out and delivers them in a thin web to other rollers, which carry them to the front of the machine. These webs, usually six, are collected, condensed and coiled in a can ready for the drawing frame. The process is intermittent, and each operation is called a nip. About 80 nips a minute is the average speed. There is also on the market what is known as a duplex comber, where there are two sets of needles and two fluted segments. This machine can be run at a speed of 120 nips, with a corresponding increase in production. The work is not as thorough as on the slower machine, and is not suited for very fine work.

The comber is a very ingenious machine, and requires the closest adjustment and attention in order to produce satisfactory results. It is much simpler than at first invented. At that time a 6-head comber had 564 parts. It now has from 200 to 220.

SETTINGS.

It is impossible to give the exact settings for a machine without taking into consideration the length of cotton to be combed. Some of the settings remain the same regardless of this, while others are changed for every change in length. There are also changes to regulate the amount of waste which it is desired to remove. The following tables give the approximate settings for the three makes of machines most frequently used in America:

SETTINGS OF MASON COMBER.

	Guage.	Dial.
Edge of fluted segment to detaching roller	1⅛	5
Feed roller to detaching roller (at bearing)	1 15/16	......
Feed roller starts	....	4¼
Edge of cushion plate to detaching roller	1¼	......
Edge of cushion plate to cylinder combs	20	......
Nippers close	....	9
Nipper screws open from bracket	¼	......
Paul drops in notch wheel	....	1¼
Leather roller touches fluted segment	....	6¾
Leather roller leaves fluted segment	....	9½
Brass roller to leather roller	14	......
Top combs down	....	5¾
Top combs to fluted segment	19	......

SETTINGS OF WHITIN COMBER.

Nippers open at	$3\frac{1}{2}$	Index
Nippers close at	$9\frac{1}{4}$	Index
Lifters down at	$6\frac{3}{4}$	Index
Lifters up at	$8\frac{3}{4}$	Index
Top Combs down	5	Index
Detaching roll comes forward at	6	Index
Feed roll comes forward at	4	Index

SETTINGS OF DOBSON & BARLOW COMBER.

	Gauge.	Dial.
Clutch closes	$20\frac{1}{4}$	......
Steel detaching roll comes forward	....	6
Nippers close	....	9
Star wheel begins to feed	....	$4\frac{3}{4}$
Top comb down	....	5
Nippers to needles	19	......

For setting the motions somewhat in the proper order, the following suggestions will be of service:

1st. Set all segments at $1\frac{1}{8}$ to $1\frac{1}{4}$ inch gauge, with index at 5.

2d. Set the cushion plates the thickness of a piece of writing paper from the nippers.

3d. Loosen all nuts on rods at back, and take the springs off.

4th. Take each head separately and set cushion plates $1\frac{1}{4}$ inches from steel detaching roller. Then put second step of step gauge between the set screws and stand, and set nippers to segment to No. 19 gauge. Take each head separately until

all have been set, replace the springs, and turn the pulley until the first row of needles comes under the nipper. It is very important to turn the needles under the nipper at this time, for if it is not done, when the comber is started the needles will be broken.

5th. When the needles come under the nipper, put 5-16, or the second step of the step-gauge, between the set screws and stand, and tighten on the top nuts or rods at back until the step-gauge drops out. Then tighten the bottom nuts.

6th. Try number 19 gauge between nippers and needles. If it is too close, draw off a little by means of the adjusting set screws.

7th. Set top comb from 18 to 21 gauge according to per centage in waste desired.

8th. Turn the pulley until the detaching cam brings the adjustable blocks to the lowest point, then set blocks No. 21 gauge from the brass bearings to the end of the leather detaching roll.

9th. Dust everything thoroughly with whiting before starting.

A comber to give good results must be oiled and cleaned very carefully, and everything set over at frequent intervals. The needles must be kept in good condition and picked out frequently. They should especially be kept free of hooked ends. Like the ribbon-lap machine, the polished parts must be frequently polished in order to obtain satisfactory results.

Waste.—Waste for Peeler stock is usually from 15 to 17 per cent, and from Sea Island from 20 to 22. The simplest way to ascertain the per cent is to carefully remove all the stock, run the machine say half a minute, and carefully weigh in grains both waste and good cotton. Add the two weights together, and divide the number of grains of waste by the sum. The quotient will be the per cent of waste.

Example.—The waste produced in half a minute is 45 grains, and the combed cotton 255 grains, what per cent of waste is removed?

$$45 + 255 = 300.$$
$$45 \div 300 = 15 \text{ per cent.}$$

The amount of waste may be increased—

1st. By feeding later.

2d. By closing nippers later.

3d. By setting the top combs at greater angle.

4th. By setting the top combs nearer to fluted segments.

The waste may be either run into boxes, rolled on a rod or coiled in a can. In any case it is reworked into coarser numbers.

Draft.—There are two places where there is a considerable draft, and a number of others where there is a slight draft, just sufficient to keep the sliver under tention.

1st. Between the steel roller and the first calender roller. This is usually from 5 to 6.

2d. Between the back roller in the draw box, and the block or second calender roller. This is usually from 4 to 4½. The total draft is from 20 to 33.

The draft constant (total draft) on a Mason comber is 424.3, on a Whiting comber 424.4, and on a Dobson and Barlow 476.1. These constants are for gears as usually sent out, but of course other gears may be used, and a different combination may result.

Production.—The production depends on the speed, weight of sliver, and the amount of waste removed. With 15 per cent allowed for waste, and 5 per cent for stoppages, the production will be as follows:

PRODUCTION TABLE OF COMBER, 10 HOURS.

Nips Per Minute.	Grains Per Yard of Combed Sliver.										
	40	42	44	46	48	50	52	54	56	58	60
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs
75	37	39	41	43	44	46	48	50	52	54	56
80	40	42	44	45	47	49	51	53	55	57	59
85	42	44	46	48	50	53	55	57	59	61	63
90	44	47	49	51	53	56	59	60	62	64	67
95	47	49	52	54	56	59	61	63	66	68	70
100	49	52	54	57	59	62	64	67	69	72	74

GENERAL INFORMATION.

A 6-head comber occupies a space of 13′ × 3′-5″, and weighs about 3,000 pounds. They cost about

$700.00 each. The first ones offered to the public cost $1,000.00, with an additional $1,500.00 for royalty. American builders usually make them to take laps $8\frac{3}{4}$ inches wide, but English builders have them $7\frac{1}{2}$, $8\frac{1}{2}$ and $10\frac{1}{2}$ inches. All Heilman combers are built almost exactly alike, regardless of the maker.

Combed yarns are much stronger and smoother than carded yarns, and at the present time are worth 6 cents more per pound. The difference depends a good deal on the price of cotton. As a large per cent of the value of combed yarn is in the waste which is taken from the material, high-priced cotton means high-priced waste.

CHAPTER IV.

THE NUMBERING OF COTTON YARN.

Until the cotton passes the drawing frame, the system of numbering or weighing involves only the weight per yard, which on the lapper is expressed in ounces, and afterwards in grains. After the cotton leaves the drawing frame, at each subsequent process it is drawn finer and finer and the weight of one yard is too delicate a matter to be accurately determined. It is customary to take the weight of 12 yards up to the spinning frame or mule, and afterwards 120 yards, or a multiple of it. The whole system is based on the fact that if 840 yards weigh one pound, the yarn or roving is called No. 1. If it takes twice 840 yards, or three times, or ten times, to make a pound, the number is 2, 3 or 10. If the stock is roving, it is called 2, 3 or 10 hank. If it is thread it is called number 2, 3 or 10. In England, it is referred to as counts. There is no difference whatever in the system of measuring roving and yarn. The term hank has two meanings which must not be confused. It may refer as above to the number of roving, or it may mean a definite length of stock, which is 840 yards. Of course there is a similarity in the two meanings, as number 10 hank roving contains 10 hanks (10×840), but number 1 hank roving and one hank of

roving or yarn may be the same and may be entirely different.

The table of weight is composed entirely of the avoirdupois table and partly of Troy, and is as follows:

$437\frac{1}{2}$ grains (Troy) = 1 oz. (avoirdupois).
16 ozs. = 1 lb. (avoirdupois).
7,000 grains (Troy) = 1 lb. (avoirdupois).

As said above, it is customary in weighing roving to take 12 yards, which is 1-70th of a hank, and for weight to take as a basis 100 grains, which is 1-70th of a pound (7,000 grains). Twelve yards of yarn is too small a quantity, so we take 120 yards (1-7th of a hank) and 1,000 grains (1-7th of a pound). If, then, we have the weight of 12 yards of roving, and wish to find the number, we have only to divide it into 100; or, if we have the weight of 120 yards of yarn and wish to find the number, we have only to divide it into 1,000. Thus, if 12 yards of roving weigh 16 grains, $100 \div 16 = 6.25$, which is the hank roving. If it were yarn instead of roving, of course 6.25 would be the number of yarn, but we would take 120 yards and divide it into 1,000, which is the same so far as results are concerned.

As the overseer has frequent occasions to know the number of roving or yarn without the trouble of this division, we give below a table which applies to roving and yarn alike.

TABLE FOR NUMBERING ROVING OR YARN.

Number of Roving or Yarn.	Weight of 12 Yards Roving.	W'ight of 120 Yards Yarn.	Number of Roving or Yarn.	Weight of 12 Yards Roving.	W'ight of 120 Yards Yarn.	Number of Roving or Yarn.	W'ight of 12 Yards of Roving.	W'ight of 120 Yards Yarn.
.20	500	......	2.25	44.4	......	5.50	18.2	182
.25	400	......	2.30	43.4	......	5.75	17.4	174
.30	333	......	2.35	42.6	......	6.00	16.7	167
.35	285	......	2.40	41.6	......	6.25	16.0	160
.40	250	......	2.45	40.8	......	6.50	15.4	154
.45	222.2	......	2.50	40.0	......	6.75	14.8	148
.50	200	......	2.55	39.2	......	7.00	14.3	143
.55	181.8	......	2.60	38.5	......	7.25	13.8	138
.60	166.6	......	2.65	37.8	......	7.50	13.3	133
.65	154	......	2.70	37.1	......	7.75	12.9	129
.70	142.8	......	2.75	36.4	......	8.00	12.5	125
.75	133.3	......	2.80	35.7	......	8.25	12.1	121
.80	125	......	2.85	35.1	......	8.50	11.7	117
.85	117.6	......	2.90	34.5	......	8.75	11.4	114
.90	111.1	......	2.95	33.9	......	9.00	11.1	111
.95	105.2	......	3.00	33.3	......	9.25	10.8	108
1.00	100	......	3.05	32.8	......	9.50	10.5	105
1.05	95.2	......	3.10	32.3	......	9.75	10.3	103
1.10	91	......	3.15	31.7	......	10.00	10.0	100
1.15	87	......	3.20	31.2	......	10.25	9.8	98
1.20	83.5	......	3.25	30.8	......	10 50	9.5	95
1.25	80	......	3.30	30.3	......	10.75	9.3	93
1.30	76.9	......	3.35	29.8	......	11.00	9.1	91
1.35	74	......	3.40	29.4	......	11.25	8.9	89
1.40	71.5	......	3.45	29.0	......	11.50	8.7	87
1.45	69	......	3.50	28.6	......	11.75	8.5	85
1.50	66.5	......	3.55	28.2	......	12.00	8.3	83
1.55	64.5	......	3.60	27.8	......	12.25	8.2	82
1.60	62.5	......	3.65	27.4	......	12.50	8.0	80
1.65	60.5	......	3.70	27.0	......	12.75	7.9	79
1.70	58.8	......	3.75	26.7	......	13.00	7.7	77
1.75	57.1	......	3.80	26.3	......	13.25	7.5	75
1.80	56.5	......	3.85	26.0	......	13.50	7.4	74
1.85	54.0	......	3.90	25.6	......	13.75	7.2	72
1.90	52.5	......	3.95	25.3	......	14.00	7.1	71
1.95	51.2	......	4.00	25.0	250	14.25	7.0	70
2.00	50.0	......	4.25	23.5	235	14.50	6.9	69
2.05	48.8	......	4.50	22.2	222	14.75	6.8	68
2.10	47.6	......	4.75	21.1	211	15.00	6.7	67
2.15	44.6	......	5.00	20.0	200	15.25	6.5	65
2.20	45.4	......	5.25	19.1	191	15.50	6.4	64

TABLE FOR NUMBERING ROVING OR YARN—*Continued.*

Number of Roving or Yarn.	Weight of 12 Yards Roving.	W'ight of 120 Yards Yarn.	Number of Roving or Yarn.	Weight of 12 Yards Roving.	W'ight of 120 Yards Yarn.	Number of Roving or Yarn.	W'ight of 12 Yards of Roving.	W'ight of 120 Yards Yarn.
15.75	6.3	63	26.00	....	38.4	36.25	......	27.6
16.00	6.2	62	26.25	....	38.1	36.50	......	27.4
16.25	6.2	62	26.50	....	37.7	36.75	......	27.2
16.50	6.1	61	26.75	....	37.4	37.00	......	27
16.75	6.0	60	27.00	....	37	37.25	......	26.8
17.00	5.9	59	27.25	....	36.7	37.50	......	26.6
17.25	5.8	58	27.50	....	36.3	37.75	......	26.5
17.50	5.7	57	27.75	....	36	38.00	......	26.3
17.75	5.6	56	28.00	....	35.7	38.25	......	26.1
18.00	5.5	55	28.25	....	35.4	38.50	......	26
18.25	....	54.8	28.50	....	35.1	38.75	......	25.8
18.50	....	54	28.75	....	34.8	39 00	......	25.6
18.75	....	53.4	29.00	....	34.5	39.25	......	25.5
19.00	....	52.6	29.25	....	34.2	39.50	......	25.2
19.25	....	51.9	29.50	....	33.9	39.75	......	25.1
19.50	....	51.3	29.75	....	33.6	40.00	......	25
19.75	....	50.6	30.00	....	33.3	40.25	......	24.8
20.00	....	50	30.25	....	33.1	40.50	......	24.7
20.25	....	49.4	30.50	....	32.8	40.75	......	24.5
20.50	....	48.8	30.75	....	32.5	41.00	......	24.3
20.75	....	48.2	31.00	....	32.2	41.25	......	24.2
21.00	....	47.6	31.25	....	32	41.50	......	24.1
21.25	....	47.1	31.56	....	31.9	41.75	......	24
21.50	....	46.5	31.75	....	31.5	42.00	......	23.8
21.75	....	46	32.00	....	31.2	42.25	......	23.7
22.00	....	45.4	32.25	....	31	42.50	......	23.5
22.25	....	45	32.50	....	30.7	42.75	......	23.4
22.50	....	44.4	32.75	....	30.5	43.00	......	23.2
22.75	....	44	33.00	....	30.3	43.25	......	23.1
23.00	....	43.4	33.25	....	30.1	43.50	......	23
23.25	....	43	33.50	....	29.8	43.75	......	22.9
23.50	....	42.5	33.75	....	29.6	44.00	......	22.7
23.75	....	42.1	34.00	....	29.4	44.25	......	22.6
24.00	....	41.6	34.25	....	29.2	44.50	......	22.4
24.25	....	41.3	34.50	....	29	44.75	......	22.3
24.50	....	40.8	34.75	....	28.8	45.00	......	22.2
24.75	....	40.4	35.00	....	28.5	45.25	......	22.1
25.00	....	40	35.25	....	28.4	45.50	......	22
25.25	....	39.6	35.50	....	28.2	45.75	......	21.9
25.50	....	39.2	35.75	....	28	46.00	......	21.7
25.75	....	38.8	36.00	....	27.7	46.25	......	21.6

TABLE FOR NUMBERING ROVING OR YARN—*Continued.*

Number of Roving or Yarn.	Weight of 12 Yards Roving.	W'ight of 120 Yards Yarn.	Number of Roving or Yarn.	Weight of 12 Yards Roving.	W'ight of 120 Yards Yarn.	Number of Roving or Yarn.	W'ight of 12 Yards of Roving.	W'ight of 120 Yards Yarn.
46.50	....	21.5	52.00	....	19.2	61.00	......	16.4
46.75	....	21.4	52.50	....	19.0	61.50	......	16.3
47.00	....	21.2	53.00	....	18.9	62.00	......	16.1
47.25	....	21.1	53.50	....	18.7	62.50	......	16.0
47.50	....	21.0	54.00	....	18.5	63.00	......	15.9
47.75	....	20.9	54.50	....	18.4	63.50	......	15.7
48.00	....	20.8	55.00	....	18.2	64.00	......	15.6
48.25	....	20.7	55.50	....	18.0	64.50	......	15.5
48.50	....	20.6	56.00	....	17.8	65.00	......	15.4
48.75	....	20.5	56.50	....	17.7	65.50	......	15.3
49.00	....	20.4	57.00	....	17.5	66.00	......	15.1
49.25	....	20.3	57.50	....	17.4	66.50	......	15.0
49.50	....	20.2	58.00	....	17.2	67.00	......	14.9
49.75	....	20.1	58.50	....	17.0	67.50	......	14.8
50.00	....	20.0	59.00	....	16.9	68.00	......	14.7
50.50	....	19.8	59.50	....	16.8	68.50	......	14.6
51.00	....	19.6	60.00	....	16.6	69.00	......	14.5
51.50	....	19.4	60.50	....	16.5	69.50	......	14.4

SLUBBERS AND FLY FRAMES.

As said in the beginning of this book, it is assumed that the reader is familiar with the machinery in a general way, and no extended description of the processes is given. So far as the useful work is concerned, a slubber is the same as a drawing frame; that is, it attenuates or draws out the strands into smaller ones. The matter of twisting and winding on bobbins is simply to facilitate the subsequent processes. The matter of twist is a very vital one, however, as on it depends not only the subsequent processes, but also the production. The spindles run at a uniform speed, and if any variation of twist is wanted, it is made by changing the speed of the rollers. There is a maxim among carders never to change twist in order to gain production. This is subject to severe criticism. We once knew of a mill where part of the spinning was frequently stopped on account of lack of roving. A new carder took part of the twist from the roving, and there was soon plenty to spare. As the solid contents of cylindrical bodies varies as the square of their diameters, and as twist is governed by the size of roving, it has become a custom to regulate it according to the square root of the number. American machine builders have a uniform standard of 1.2 multiplied by the square root of the number. English builders use

1, 1.1 and 1.2 for the slubber, immediate and roving frames respectively. In either case this is for ordinary cotton. Long-staple cotton can be run with much less twist. The amount of twist in fine roving is not governed so much by the running qualities of the machine, as by the ability of the roving to turn the bobbin and skewer as it is used in the spinning frame or mule. It is the opinion of the writer that very few mills run roving from 3 to 6 hank with standard twist. The roving will be too tender to turn the bobbin, and will be continually breaking. On the other hand, it is very easy to get too much twist, which will cause a loss of production, and by its hard nature injure the rollers in the spinning frames. Under ordinary conditions, if the roving is strong enough, it will work better just at that point than if it were twisted harder. There are some spinners who claim that spinning runs better if the roving is twisted beyond this point, but the writer fails to see any good reason why this should be the case.

For the same reason that the twist is governed by the square root of the number, the lay of the roving also depends upon it. It is generally calculated at 12 times the square root of the number. This matter seldom receives the attention it deserves from overseers. It is true the frame will run with a very wide variation either way; that is, it will run for a while. If the lay

is not right, the tension soon gets wrong, with all its resultant evils. If it is too tight, the roving may be very injuriously stretched before the attendant changes it. It is always bad management to have the attendant constantly doing this as the bobbin fills up, and is a sure sign that something is wrong. Except for slight changes, caused by damp weather, the tension should always remain the same.

A fly frame has more bearing surfaces than any other machine in the mill, and for this reason should receive more careful alignment and oiling than any other. Not only does lack of oil cause friction and unnecessary power, but it is the most fruitful cause of breakdowns and consequent loss of production. When the average fixer finds a steady-pin broken, or gear loose, he usually thinks it is the natural wear of the machine, and does not stop to consider that lack of oil or binding in the bearings may be the cause of the trouble.

The primary motions of the fly frame are the same as they were forty or fifty years ago, but matters of detail have been much improved. The compound motion as now built requires much less power and attention than formerly. The spindles have better oiling arrangements, the gears may be more easily changed, and there are many other minor improvements.

CALCULATIONS.

The three principal calculations on speeders are twist, draft and production. There are several others, as lay, tension and taper, but these, when once ascertained, are more simple, and will not be considered in detail.

Twist.—If a speeder be considered for a fraction of a second, one end of the strand of roving is held by the rollers, while the other is turned by the flyer, and twist is produced. In practice neither end is held rigidly, and the flyer winds on the bobbin just as much as is delivered by the front rollers. This is not absolutely true, as a little more is wound as the carriage goes up, and a little less as it goes down. If the flyer turns one time, or ten times, while the rollers deliver one inch, the twist is one turn or ten turns per inch. A detailed calculation for ascertaining the proper gear to produce so many turns per inch is very elaborate, and need not be given here. The best way to ascertain the twist is to mark a bobbin and slowly turn the speeder by hand until the front roller has made one revolution. As the diameter is usually $1\frac{1}{8}$ inches, one revolution will deliver $1\frac{1}{8} \times 3.1416 = 3.5343$ inches. This divided into the turns of the spindle, say 20, $= 5.65$ per inch. This is known as the theoretical twist, but is not the actual twist, as the 3.5343 inches is a little shorter after being twisted, and consequently the actual twist is more than the

theoretical. A good method to determine the actual twist is to blacken several inches of one strand of roving in the creel. After it is drawn through, the turns may be readily counted, as the blackened thread is distinct from the white one.

Rule for changing twist gear when changing from one number of roving to another:

Multiply the square of the gear used by the hank being made, divide the product by the hank required, and the square root of the quotient will be the gear needed.

Example.—Suppose we are making a 5-hank roving with a 28 gear. What gear will be needed for 3-hank?

$$28 \times 28 \times 5 = 3920$$
$$3920 \div 3 = 1306$$
$$\sqrt{1306} = 36$$

This is perhaps the easiest way where the square root is understood. Where it is not, a simpler way is to first find the actual twist per inch being put in, when the question becomes one of simply proportion. Suppose in the above case, 2.68 turns were being put into a 5-hank roving, and in 3-hank there should be 2.08, what gear is required?

Rule.—*Multiply the gear now used by the twist being used, and divide by the twist required. The quotient will be the gear required.*

$$28 \times 2.68 = 75.04.$$
$$75.04 \div 2.08 = 36.$$

This works out the same as before.

For many reasons it is desirable to have a table giving the correct twist for roving, and below it is given in detail.

TWIST OF ROVING.

Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist. 1.2× sq. root.	Hank roving.	Twist 1.2 × sq. root.
.20	.54	.57	.91	1.08	1.25	1.82	1.62
.21	.55	.58	.91	1.10	1.26	1.84	1.63
.22	.56	.59	.92	1.12	1.27	1.86	1.64
.23	.58	.60	.93	1.14	1.28	1.88	1.65
.24	.59	.61	.94	1.16	1.29	1.90	1.65
.25	.60	.62	.94	1.18	1.30	1.92	1.66
.26	.61	.63	.95	1.20	1.31	1.94	1.67
.27	.62	.64	.96	1.22	1.33	1.96	1.68
.28	.63	.65	.97	1.24	1.34	1.98	1.69
.29	.65	.66	.97	1.26	1.35	2.00	1.70
.30	.66	.67	.98	1.28	1.36	2.02	1.71
.31	.67	.68	.99	1.30	1.37	2.04	1.71
.32	.68	.69	1.00	1.32	1.38	2.06	1.72
.33	.69	.70	1.00	1.34	1.39	2.08	1.73
.34	.70	.71	1.01	1.36	1.40	2.10	1.74
.35	.71	.72	1.02	1.38	1.41	2.12	1.75
.36	.72	.73	1.02	1.40	1.42	2.14	1.76
.37	.73	.74	1.03	1.42	1.43	2.16	1.76
.38	.74	.75	1.04	1.44	1.44	2.18	1.77
.39	.75	.76	1.05	1.46	1.45	2.20	1.78
.40	.76	.77	1.05	1.48	1.46	2.22	1.79
.41	.77	.78	1.06	1.50	1.47	2.25	1.80
.42	.78	.79	1.07	1.52	1.48	2.28	1.81
.43	.79	.80	1.07	1.54	1.49	2.31	1.82
.44	.80	.82	1.09	1.56	1.50	2.34	1.84
.45	.80	.84	1.10	1.58	1.51	2.37	1.85
.46	.81	.86	1.11	1.60	1.52	2.40	1.86
.47	.82	.88	1.13	1.62	1.53	3.43	1.87
.48	.83	.90	1.14	1.64	1.54	2.46	1.88
.49	.84	.92	1.15	1.66	1.55	2.49	1.89
.50	.85	.94	1.16	1.68	1.56	2.52	1.90
.51	.86	.96	1.18	1.70	1.56	2.55	1.92
.52	.87	.98	1.19	1.72	1.57	2.58	1.93
.53	.87	1.00	1.20	1.74	1.58	2.61	1.94
.54	.88	1.02	1.21	1.76	1.59	2.64	1.95
.55	.89	1.04	1.22	1.78	1.60	2.67	1.96
.56	.90	1.06	1.24	1.80	1.61	2.70	1.97

TWIST OF ROVING—*Continued.*

Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist 1.2 × sq. root.
2.73	1.98	3.93	2.38	5.44	2.80	7.04	3.18
2.76	1.99	3.96	2.39	5.48	2.81	7.08	3.19
2.79	2.00	3.99	2.40	5.52	2.82	7.10	3.20
2.82	2.01	4.02	2.41	5.56	2.83	7.15	3.21
2.85	2.03	4.05	2.41	5.60	2.84	7.20	3.22
2.88	2.04	4.08	2.42	5.64	2.85	7.25	3.23
2.91	2.05	4.11	2.43	5.68	2.86	7.30	3.24
2.94	2.06	4.14	2.44	5.72	2.87	7.35	3.25
2.97	2.07	4.17	2.45	5.76	2.88	7.40	3.26
3.00	2.08	4.20	2.46	5.80	2.89	7.45	3.28
3.03	2.09	4.23	2.47	5.84	2.90	7.50	3.29
3.06	2.10	4.26	2.48	5.88	2.91	7.55	3.30
3.09	2.11	4.32	2.49	5.92	2.92	7.60	3.31
3.12	2.12	4.36	2.51	5.96	2.93	7.65	3.32
3.15	2.13	4.40	2.52	6.00	2.94	7.70	3.33
3.18	2.14	4.44	2.53	6.04	2.95	7.75	3.34
3.21	2.15	4.48	2.54	6.08	2.96	7.80	3.35
3.24	2.16	4.52	2.55	6.12	2.97	7.85	3.36
3.27	2.17	4.56	2.56	6.16	2.98	7.90	3.37
3.30	2.18	4.60	2.57	6.20	2.99	7.95	3.38
3.33	2.19	4.64	2.58	6.24	3.00	8.00	3.39
3.36	2.20	4.68	2.60	6.28	3.01	8.05	3.40
3.39	2.21	4.72	2.61	6.32	3.02	8.10	3.42
3.42	2.22	4.76	2.62	6.36	3.03	8.15	3.43
3.45	2.23	4.80	2.63	6.40	3.04	8.20	3.44
3.48	2.24	4.84	2.64	6.44	3.05	8.25	3.45
3.51	2.25	4.88	2.65	6.48	3.05	8.30	3.46
3.54	2.26	4.92	2.66	6.52	3.06	8.35	3.47
3.57	2.27	4.96	2.67	5.56	3.07	8.40	3.48
3.60	2.28	5.00	2.68	6.60	3.08	8.45	3.49
6.63	2.29	5.04	2.69	6.64	3.09	8.50	3.50
3.66	2.30	5.08	2.70	6.68	3.10	8.55	3.51
3.69	2.31	5.12	2.72	6.72	3.11	8.60	3.52
3.72	2.31	5.16	2.73	6.76	3.12	8.65	3.53
3.75	2.32	5.20	2.74	6.80	3.13	8.70	3.54
3.78	2.33	5.24	2.75	6.84	3.14	8.75	3.55
3.81	2.34	5.28	2.76	6.88	3.15	8.80	3.56
3.84	2.35	5.32	2.77	6.92	3.16	8.85	3.57
3.87	2.36	5.36	2.78	6.96	3.17	8.90	3.58
3.90	2.37	5.40	2.79	7.00	3.17	8.95	3.59

TWIST OR ROVING—*Continued.*

Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist. 1.2 × sq. root.	Hank roving.	Twist. 12 × sq. root.	Hank roving.	Twist. 1.2 × sq. root.
9.00	3.60	**11.10**	4 00	**13.50**	4.41	**16.10**	4.81
9.05	3.61	11.16	4.01	13.56	4.42	16.17	4.83
9.10	3.62	11.22	4.02	13.62	4.43	16.24	4.84
9.15	3.63	11.28	4.03	13.68	4.44	16.31	4.85
9.20	3.64	11.34	4.04	13.74	4.45	16.38	4.86
9.25	3.65	11.40	4.05	13.80	4.46	16.45	4.87
9.30	3.66	11.46	4.06	13.86	4.47	16.52	4.88
9.35	3.67	11.52	4.07	13.92	4.48	16.59	4.89
9.40	3.68	11.58	4.08	13.98	4.49	16 66	4.90
9.45	3.69	11.64	4.09	14.04	4.50	16.73	4.91
9.50	3.70	**11.70**	4.10	**14.10**	4.51	**16.80**	4.92
9.55	3.71	11.76	4.12	14.16	4.52	16.87	4.93
9.60	3.72	11.82	4.13	14.22	4.53	16.94	4 94
9.65	3.73	11.88	4.14	14.28	4.53	17.01	4.95
9.70	3.74	11.94	4.15	14.34	4.54	17.08	4.96
9.75	3.75	12.00	4 16	14.40	4.55	17.15	4.97
9.80	3.76	12.06	4.17	14.46	4.56	17.22	4.98
9.85	3.77	12.12	4.18	14.52	4.57	17.29	4.99
9.90	3.78	12.18	4.19	14.58	4.58	17.36	5.00
9.95	3.79	12.24	4.20	14.64	4.59	17.43	5.01
10.00	3.79	**12.30**	4.21	14 70	4.60	**17.50**	5.02
10.05	3.80	12.36	4.22	14.76	4.61	17.57	5.03
10.10	3.81	12.42	4.23	14 84	4.62	17.64	5.04
10.15	3 82	12 48	4.24	14.91	4.63	17.71	5.05
10.20	3.83	12.54	4.25	14.98	4.64	17.78	5.06
10.25	3.84	12.60	4.26	15.05	4.66	17.85	5.07
10.30	3.85	12 66	4.27	15.12	4 67	17.92	5.08
10.35	3 86	12.72	4.28	15.19	4.68	17.99	5.09
10.40	3.87	12.78	4.29	15.26	4 69	18.06	5.10
10.45	3.88	12.84	4.30	15.33	4.70	18.13	5.11
10.50	3 89	**12.90**	4.31	**15.40**	4.71	**18.20**	5.12
10.55	3 90	12.96	4.32	15.47	4.72	18.27	5 13
10.62	3.91	13.02	4.33	15.54	4.73	18.34	5.14
10.68	3.92	13.08	4.34	15.61	4.74	18.41	5.15
10.74	3.93	13.14	4.35	15.68	4.75	18.48	5.16
10.80	3.94	13.20	4.36	15.75	4.76	18.55	5.17
10.86	3.95	13.26	4.37	15.82	4.77	18.62	5.18
10 92	3.97	13.32	4.38	15.89	4.78	18.69	5.19
10.98	3.98	13.38	4.39	15.96	4.79	18.76	5.20
11.04	3.99	13.44	4.40	16.03	4.80	18.83	5.21

Lay and Tension Gears.—The rule for finding these is exactly the same as for the twist; either rule will give the same result.

Draft.—The rule for finding the draft is the same as given for cards, viz.:

Rule.—*Consider the back roller the driver. Multiply all the driving gears, and the diameter of the front roller for a numerator, and divide the product by the product of the driven gears, and the diameter of the back roller as a denominator.*

Take, for instance, a frame having the following gears:

Driving gears—	Driven gears—
Back roller, 50.	Change gear, 36.
Crown gear, 80.	Front roller gear, 22.

Diameter of front roller, $1\frac{1}{8}''$—consider it 9 (eighths).

Diameter of back roller, $1''$—consider it 8 (eighths).

$$\frac{9 \times 50 \times 80}{8 \times 36 \times 22} = 5.7 \text{ (about)} = \text{draft.}$$

Note.—The front roller of a slubber and intermediate is usually $1\frac{1}{4}$ inches $= 10$ (eighths).

In practice the draft of these machines is calculated by the net results. If one hank roving is fed to a machine, two ends being run together, which would make the hank .50, and 2.50 hank is produced, the draft is evidently $2.50 \div .50 = 5$.

We had intended giving the draft and other change gears for all the most important makes of roving frames, but find that if carried out it would make the book entirely too large. We therefore give only the constants, from which the overseer can readily make a table to suit his peculiar needs.

TABLE OF CONSTANTS. PROVIDENCE FRAME.

Size.	Twist	Draft.	Traverse.	Tension.	Cone Gears.	Taper Gears.
12×6 S	32.81	157.50	21.60	22.80	28, 29, 30	18, 19, 20
11×5½ S	32.81	157.50	21.60	22.80	28, 29, 30	18, 19, 20
10×5 S	32.81	157.50	24.50	28.28	37, 38, 39	17, 18, 19
9×4½ S	41.17	157.50	32.88	34.25	28, 29, 30	16, 17, 18
10×5 I	39 76	157.50	26.20	35 28	37, 38, 39	17, 18, 19
9×4½ I	49.71	157.50	34.50	42.80	28, 29, 30	16, 17, 18
8×4 I	52.92	170.27	49.20	46.00	28, 29, 30	14, 15, 16
8×3½ I	63.25	170.27	52.80	56.10	28, 29, 30	14, 15, 16
7×3½ R	68.03	170.27	53.60	68.03	33, 34, 35	14, 15, 16
7×3 R	82.82	170.27	64.20	76.30	33, 34, 35	13, 14, 15
6×3 R	82.82	170.27	64.20	76.30	31, 32, 32	13, 14, 15
6×2½ J	88.73	170.27	91.	84.	33, 34, 35	13, 14, 15
5×2½ J	94.63	170.27	80.	132.	35, 36, 37	12, 13, 14
4½×2¼ J	94.63	170.27	88.	132.	35, 36, 37	12, 13, 14

Constant÷Draft=Draft Gear.

Constant÷Twist per inch=Twist Gear.

Constant÷Twist per inch=Traverse Gear.

Constant÷Twist per inch=Tension Gear.

NOTE—Some builders refer to traverse as lay, and to tension as contact.

TABLE OF CONSTANTS, WOONSOCKET FRAME.

Size.	Twist.	Draft	Lay.	Lay.	Contact.	Contact.	Cone Gear	Cone Gear.
12×6	32.689	175	19.676	20.023	29.962	34.1136	33	33
11×5½	32.689	175	19.676	20.023	29.962	34.1136	33	33
10×5	28.994	175	18.327	17.074	29.949	27.509	43	40
9×4½	28.994	175	18.327	17.074	29.949	27.509	43	40
10×5	40.59	175	24.635	25.286	39.384	33.714	43	40
9×4½	40.59	175	24.635	25.286	39.384	33.714	43	40
8×4	50.337	180	38.178	29.698	43.127	45.254	31	31
8×3½	60.404	180	38.178	33.940	43.127	45.254	31	31
7×3½	71.19	180	50.456	44.72	57.664	67.08	30	30
7×3	71.19	180	50.456	44.72	57.664	67.08	30	30
6×3	71.19	180	50.456	49.749	57.664	86.231	30	36
6×2½	146.918	180	79.184	79.196	127.260	141.42	36	36
5×2½	146.918	180	79.184	79.196	127.260	141.42	36	36
4×2¼	146.918	180	79.184	79.196	127.260	141.42	36	36

NOTE.—The second set of figures for Lay, Contact and Cone are for new frames equipped with Daly's Differential motion.

Constant ÷ Draft = Draft Gear.

Constant ÷ Sq. Root of No. = Lay Gear.

Constant ÷ Sq. Root of No. = Contact Gear.

Constant ÷ Twist per inch = Twist Gear.

TABLE OF CONSTANTS, SACO-PETTEE FRAME.

Size.	Twist.	Draft.	Tra-verse.	With Gears.	Ten-sion.	With Gears.	Com-pound Change	Cone Gear.
12×6	49.98	201.51	18.249	38&47	30.41	60 & 50	19	16
11×5½	43.93	201.51	29.43	38&47	35.632	55 & 55	21	16
10×5	43.93	201.51	29	38&37	43	30 & 55	21	19
9×4½	43.93	201.51	29	38&47	44	55 & 55	21	19
10×5	43.93	201.51	29	38&47	44	55 & 55	21	19
9×4½	43.93	201.51	29	38&47	44	55 & 55	21	19
8×4	62.08	190.90	44.33	25&60	52.65	55 & 55	26	19
8×3½	62.08	190.90	57.164	20&60	77.44	55 & 55	32	19
7×3½	123.83	190.90	57.164	20&60	77.44	55 & 55	32	19
7×3	131.10	180.30	99.43	14&71	101.98	55 & 55	33	19
6×3	131.10	180.30	99.43	14&71	101.98	55 & 55	33	19
6×2½	131.10	180.30	105.32	14&71	117.57	50 & 60	33	19
5×2½	131.10	180.30	98.03	14&71	183.41	35 & 75	33	19

NOTE.—The traverse and tension constants are correct only when the given combinations of years are used. Other combinations are sometimes used.

Constant ÷ Draft = Draft Gear.

Constant ÷ Twist per inch = Twist Gear.

Constant ÷ Sq Root of No. = Traverse Gear.

Constant ÷ Sq. Root of No. = Tension Gear.

TABLE OF CONSTANTS. LOWELL FRAME.

Size.	Draft.	Twist.	Tension.	Gear on Rack Shaft.	Lay.
12 ×6	148.93	31.25	28.80	....	38.4
11 ×5½	148.93	31.25	28.80	....	38.4
10 ×5	148.93	30.24	38.6	....	31.
9 ×4½	148.93	30.24	38.6	....	31.
10 ×5 I.	189.18	37 49	38.4	....	35.
9 ×4½ I.	189.18	37.49	38.4	....	35.
8 ×4	170.27	50.9	52.7	....	42.5
8 ×3½	170.27	67.59	66.	40	78.
7 ×3½	170.27	90.13	99.6	....	75.4
6 ×3	170.27	120.17	115.6	40	148.
6 ×3	170.27	120.17	139.4	56	148.
5 ×2½	170.27	120.17	137.4	56	162.88
4½×2¼	170.27	120.17	137.4	56	162.88

NOTE—The Draft Constant is figured for 100 Crown Gear.
Constant ÷ Draft=Draft Gear.
Constant ÷ Twist per inch=Twist Gear.
Constant ÷ Twist per inch=Tension Gear.
Constant ÷ Twist per inch=Lay Gear.

Production.—The calculation for production is very simple, being only a matter of speed of the front roller. It seems to us to be a waste of time to calculate this speed from that of the main shaft, as it is a very easy matter to count the actual speed or to get it with a speed indicator.

Rule.—*Multiply the circumference of the front roller by the speed per minute, the minutes in an hour, the hours in a day, and the number of spindles in a frame. Divide the product by 840 multiplied by 36 and the number of roving.*

Example.—Suppose a frame has 120 spindles on 4-hank roving. What is the production per day of 11 hours, if the front roller makes 140?

$$\frac{3.53\ (1\tfrac{1}{8} \times 3.14) \times 140 \times 60 \times 11 \times 120}{840 \times 36 \times 4} = 323 \text{ pounds.}$$

This is the theoretical production. The actual production will be from 10 to 20 per cent less, depending on the skill of the operative and a number of other conditions.

All speeders have clocks to register the number of hanks run per day. To calculate the pounds from the hank clock, multiply the hanks by the number of spindles, and divide by the number of roving being made. In the above example, suppose the clock registers 10.5 hanks. Then $10.5 \times 120 \div 4 = 315$ pounds.

On account of a change in the number of yarn, it is frequently necessary to increase the production on the speeder, or perhaps on the intermediate or slubber. This can often be done by making the roving a little heavier, and increasing the draft on the next machine. If a speeder is making 10 pounds per day of 1-hank roving, it will make 11 pounds of .90-hank, which multiplied by the whole number of spindles, will be a considerable increase. This can not always be done, as the next machine frequently has all the draft it can stand, but in many cases it can be done to advantage. It would seem to some superfluous

to mention this, but the writer once knew a superintendent of a 20,000-spindle mill who had never thought of it, and knew of another superintendent who increased the production of his predecessor over a thousand pounds per week by a very slight increase in the weight of the roving.

Below is given the production of speeders for different numbers, both in hanks and in pounds. This table is based on a stoppage of 15 minutes per set. If the frame is short, it can be doffed in less time, and there will be fewer stops on account of ends breaking. On the whole, the table is rather too high, and the production can not be attained except under very favorable circumstances. On long-staple cotton, where the twist is less than standard, it can frequently be exceeded.

PRODUCTION OF ROVING FRAMES FOR 10 HOURS.

Number of Roving.	Twist Per Inch.	10 Inch Space.			9 Inch Space.			8 Inch Space.			7 Inch Space.		
		Rev. of Front Roller.	Number of Ha'ks	Number of Lbs.	Rev. of Front Roller.	Number of Ha'ks	Number of Lbs.	Rev. of Front Roller.	Number of Ha'ks	Number of Lbs.	Rev. of Front Roller.	Number of Ha'ks	Number of Lbs.
.20	.54	307	11.7	58.7	------	------	------	------	------	------	------	------	------
.30	.66	250	12.5	41.6	------	------	------	------	------	------	------	------	------
.40	.76	220	12.5	31.1	266	12.7	29.3	------	------	------	------	------	------
.50	.85	195	12.0	24.0	238	12.0	24.0	------	------	------	------	------	------
.60	.93	178	11.6	19.0	219	11.9	19.9	------	------	------	------	------	------
.70	1.00	165	11.0	15.7	203	11.8	16.9	------	------	------	------	------	------
.80	1.07	154	10.6	13.0	188	11.5	14.5	214	12.7	15.9	------	------	------
.90	1.14	144	10.1	11.2	174	11.1	12.4	196	12.2	13.6	------	------	------
1.00	1.20	138	9.8	9.8	168	10.9	10.9	192	12.2	12.2	207	12.3	12.3
1.10	1.26	------	------	------	161	10.7	9.7	180	11.7	10.7	200	12.2	11.1
1.20	1.31	------	------	------	154	10.4	8.7	175	11.6	9.7	194	12.1	10.1
1.30	1.37	------	------	------	150	10.0	7.8	163	11.6	8 5	182	11.7	9.0
1.40	1.42	------	------	------	------	------	------	128	10.9	7.7	175	11.4	8.2
1.50	1.47	------	------	------	------	------	------	152	10.6	7.0	169	11.2	7.5
1.60	1.52	------	------	------	------	------	------	147	10.3	6 4	163	11.0	6.9
1.70	1.56	------	------	------	------	------	------	------	------	------	162	10.0	5.9

NOTE—The front roller for 10, 9, 8, and 7 inch space is $1\frac{1}{4}$; for narrower space $1\frac{1}{8}$.

PRODUCTION OF ROVING FRAMES FOR 10 HOURS.

Numb'r of Roving.	Twist Per Inch.	6 Inch Space.			5 Inch Space.			4½ Inch Space.			4¼ Inch Space.		
		Rev. of Front Roller.	No. of Hanks	No. of Pounds	Rev. of Front Roller.	No. of Hanks	No. of Pounds.	Rev. of Front Roller.	No. of Hanks	No. of Pounds	Rev. of Front Roller.	No. of Hanks	No. of Pounds
1.00	1.20	271	12.9	12.9	......	......	......	......	......	......	......	......	......
1.25	1.34	239	12.5	10.0	......	......	......	......	......	......	......	......	......
1.50	1.47	219	12.2	8.1	......	......	......	......	......	......	......	......	......
1.75	1.58	207	12.0	6.9	......	......	......	......	......	......	......	......	......
2.00	1.70	187	11.2	5.6	216	11.7	5.9	......	......	......	......	......	......
2.25	1.80	181	11.1	4.9	203	11.3	5.5	......	......	......	......	......	......
2.50	1.89	168	10.5	4.2	191	11.1	4.4	......	......	......	......	......	......
2.75	1.98	161	10.2	3.7	183	10.8	3.9	......	......	......	......	......	......
3.00	2.08	155	9.9	3.3	175	10.6	3.5	......	......	......	......	......	......
3.50	2.24	......	......	......	165	10.2	2.9	......	......	......	......	......	......
4.00	2.40	......	......	......	150	9.6	2.4	155	9.6	2.4	......	......	......
4.50	2.54	......	......	......	144	9.3	2.0	150	9.4	2.1	......	......	......
5.00	2.68	......	......	......	134	8.7	1.7	139	8.9	1.8	......	......	......
5.50	2.81	......	......	......	129	8.5	1.5	134	8.7	1.6	......	......	......
6.00	2.94	......	......	......	124	8.2	1.4	128	8.4	1.4	......	......	......
6.50	3.06	......	......	......	......	......	......	123	8.1	1.2	......	......	......
7.00	3.17	......	......	......	......	......	......	117	7.7	1.1	......	......	......
7.50	3.29	......	......	......	......	......	......	112	7.4	.99	......	......	......
8.00	3.39	......	......	......	......	......	......	112	7.3	.93	132	8.48	1.06
9.00	3.60	......	......	......	......	......	......	......	......	......	126	8.19	.914
10.00	3.79	......	......	......	......	......	......	......	......	......	120	7.90	.790
11.00	3.99	......	......	......	......	......	......	......	......	......	114	7.55	.687
12.00	4.16	......	......	......	......	......	......	......	......	......	108	7.20	.600
13.00	4.33	......	......	......	......	......	......	......	......	......	105	7.06	.543
14.00	4.49	......	......	......	......	......	......	......	......	......	99	6.68	.477
15.0	4.64	......	......	......	......	......	......	......	......	......	95	6.43	.429

TROUBLES ENCOUNTERED IN RUNNING ROVING FRAMES

Cut or Uneven Roving.—Assuming that the drawing is all right, the most fruitful source of this trouble is lack of oil on the rollers. The worst case the writer ever saw was from this cause. For some reason the slubber tenders had been changed several times within two weeks, and none of them had oiled the rollers. Before the trouble was located a large quantity of stock was in process, and an immense amount of bad work resulted. The front top rollers should always be shells, and every Saturday evening they should be removed and the arbors wiped dry. On Monday when they are replaced they, as well as the middle and back rollers, should be carefully oiled.

It sometimes happens that from the lack of oil on previous occasions, the saddles and stirrups have worn to an exact fit, and if the rollers get the least bit out of alignment they will bind and stop momentarily. This will of course cause cut roving. Very bad work has also resulted from one or two teeth being broken from a gear, sometimes by design, and when the blank space comes around, the middle or back roller stops a little, while the others go on. Occasionally, for one reason or another, a few of the roller weights are taken off, and when replaced are put back wrong, that is, the heavy ones are put on the

roller where the light ones were. This will cause trouble which is very hard to locate. Excessive draft will always cause uneven roving. The question will of course arise, what draft is excessive? A general rule is that 4, 5 and 6 should be the maximum on slubber, intermediate, and fine frames respectively. If jacks are used, not over $6\frac{1}{2}$ should be drawn. This is not a rigid rule, and circumstances may arise where these drafts may be exceeded.

In process of time, gears may break or wear out, and be replaced by others of a slightly different size. This may throw the distribution of drafts wrong, and cause a great deal of trouble. Where shell rollers are used, and two of an unequal size are put on the same arbor, the larger part of the weight is evidently on the ends, and as the roving traverses back and forth over the heavily and lightly weighted parts, the draft is sure to be affected. When the top rollers are not in line with the bottom rollers, bad work is likely to result, and besides shorten the life of the roller from 25 to 50 per cent. All cap-bars should be set with a gauge, which is simply two boards nailed at hight angles to each other. The wider one, which rests on the steel roller, has projecting fingers, which are spaced exactly as the top rollers are to be spaced. These fingers fit into the nebs of the cap bars, and when they are tightened every roller will be in exactly the same position.

In a previous paragraph, we called attention to the necessity of having the proper tention between the front rollers and the flyers. If there is a draft, it will certainly be irregular and cause irregular roving. We once knew of a new frame being started where this draft was so great that a change in the draft gear had but little effect on the weight of roving, and for some time the overseer and superintendent were literally at their wits end to know where the trouble was. When roving is cut at regular intervals it is easy to trace the cause. If the thin places are about 3½ inches apart, it is very likely there is a bad lap on the top roller, which is a very frequent cause of trouble. If the spaces are, say, a foot apart, they are probably caused by a bad middle roller. The whole question is one which should receive the closest attention from the overseer.

Tangled Bobbins.—This trouble may be, and frequently is, caused by an improper taper. As is explained under calculations, the layers of roving should be so that they will just touch, the proper number per inch being twelve times the square root of the number of roving. Each successive layer should have one row less, so that each strand will lay in the hollow formed by the two strands directly under it. If the taper is too steep, with rough treatment some of the strands will slip off. Tangled bobbins are frequently made by the frame failing to change, and

the traverse running over or under. On frames using a screw-builder motion, like the Providence, Woonsocket or Lowell, the spiral spring may be out of fix, but more frequently the end of the sliding jaws have become so worn that the motion does not change at exactly the proper time. This trouble may be overcome by filing the arm, and putting on a steel plate, which of course has a square end. In time the bevel gears either on the upright shaft or the top cone shaft, may become worn so that the teeth fail to engage. This may frequently be remedied, at least temporarily, by raising the upright shaft and putting packing in the step. A copper penny is the exact size, and answers the purpose well. If it is the large or skip gear which is worn, as usually only two or three teeth are affected, it may be made as good as new by changing from a right-hand to a left-hand frame. By this means, the teeth on the opposite side of the skip, which are not worn, are brought into use.

If the ratchet-gear builder motion is used, such as is generally on English frames, the arms which cause the change, sometimes called triggers, become worn so that they are not exactly square. Round corners will cause the motion to change at irregular times, and a bad taper is the result. When they first begin to wear, they may be filed square, but soon become too short, and have to be replaced. In setting this motion,

care must be taken that when the carriage is in the center, the poker-stick, or toothed lever, be exactly level.

Ends Slacking Down.—When the ends suddenly slack down and tangle at the flyer, a cone belt has either broken, or a gear slipped. It is when the ends slack and perhaps not tangle badly, that the real trouble is encountered. This may often be caused by the cone-belt slipping. For a test, some one may tighten the belt by pressing the cone down with the foot. If this is not the trouble, it may be a set screw slipping. If a trial with a wrench fails to find a loose one, all the important gears in the train from the compound motion to the bobbin may be marked with chalk or a punch, and the frame again started. This will show where the slip is. If the trouble always occurs at a certain point in the lift, it is good evidence that a motion somewhere is binding, and causing the cone-belt to slip. It is sometimes necessary to disconnect the whole bobbin motion, and turn the compound by hand until the trouble is located. Most of the trouble of this nature is the result of careless oiling. The oiler may think he is oiling every place, but it does not take long for an oil-hole to get choked with lint, and the oil wasted.

Hard Ends.—This is the general name for the trouble when the roving comes through without being drawn. It is usually caused by bad piece-

ing in the previous process. When an end breaks down, the speeder-tender in piecing it up generally wets the end so it can be readily threaded through the eye of the flyer. If this wet and twisted end is not broken off before piecing up, when it comes to the next machine it will not draw. It is not unusual for the speeder-tender to put in twice the usual twist in order that the roving may easily stand the strain of threading it through the flyer. Even if the wet end is broken off, the roving will often fail to draw. The remedy is to have the attendant put in just as little twist as will enable him to piece up the ends.

There will also be hard ends when the rollers are set too close for the length of staple. Two rollers, having hold of the fibers at the same time, it is obvious that they will not be drawn. The remedy is to have the rollers further apart. The front and middle should be set so that the bite is 1-16 inch further apart than the length of the sliver. The middle and back roller may be 2-16ths. For further explanation, see "Setting of Drawing-Frame Rollers."

There is a great deal written about excessive drafts, but very little about deficient drafts. As a matter of fact, there can be too little draft on the speeder, and when this is the case hard ends, or undrawn roving, is the result. Where only

a sample is wanted, the trouble may be stopped by taking the weight off the middle roller.

Black Oil.—This is a trouble always to be guarded against. A certain amount of oil may get on the roving when oiling the rollers, but this is not the chief trouble. In all well-regulated mills, the speeder-tenders are required to oil the spindles after the first doff in the morning. As the frame runs, more or less lint will stick to the oily spindles, and when the frame is again ready to doff, there will be a small collar of oily lint around the spindle at the top of the bobbin. If this is thrown off carelessly in the box with the roving, it is almost sure to stain it. The remedy is to remove the oily waste before doffing. Of course it is some trouble, but where the goods are fine, a yard is worth something, and one black thread may throw the whole piece into seconds. Where the goods are not so fine, this trouble is not so likely to occur, as a frame doffs too often to accumulate waste. These black specks can not always be readily removed before doffing, and can frequently be seen on the roving in the creels. The speeder-hands or spinners should be trained to carefully pick off all they see.

Yellow oil may get on the cotton at almost any time. It must be carefully guarded against. Yellow crayon should not be used, as it is often mistaken for oil. For a similar reason very

deep colors should not be used, as they will certainly show in the finished cloth.

Clearer Waste in Roving.—This may be avoided by having the clearers picked more often. It is of great importance that this be done, for if not the waste will occasionally be licked up by the roving, or it may drop in a mass to the roving and make a heavy slub. This will usually break back at the spinning frame, but if it does not, a long thick place is made in the yarn. On long-staple cotton this trouble is much more prevalent, as the rollers are too far apart to help hold the waste together.

Irregular Size Bobbins.—Where there are several makes of frames in use it is frequently the case that there are bobbins which may fit other frames, but are not exactly the same diameter. This is a very important matter, for with two sizes on a machine, it is impossible to keep the tention right. The attendant may tighten it on account of a dozen ends running slack, and thereby strain the roving on all the rest of the spindles. The machine builders will furnish blue prints, showing the exact size of the bobbins, and these should be used. All bobbins should be wired, and in a coarse mill where they are handled frequently, they should have a metal base. These cost a good deal more, but are much cheaper in the end.

GENERAL INFORMATION.

The price of speeders vary greatly. The combination price for machines of standard length is as follows:

12×6	inch slubber, 60 spindles	$13.10
11×5½	inch slubber, 60 spindles	12.29
10×5	inch intermediate, 72 spindles	9.97
8×5	inch intermediate, 96 spindles	7.22
7×3½	inch roving, 144 spindles	6.00
6×3	inch roving, 160 spindles	5.57

If the machine is shorter, the price per spindle will be more, and if longer, less. When a mill is organized, it is ascertained how many spindles of a certain machine will be needed. The whole number is then divided among so many machines, a uniform number of spindles for each machine being kept in mind. Slubber spindles vary by four, intermediates by six, and fine frames by eight. If the lengths are irregular, the cost will be more. The length of machines should be governed, partly at least, by the labor required to run them. Thus, a 90-spindle slubber on coarse work would be rather too much for one hand, and not enough for two. It must be borne in mind also that a short machine will produce more per spindle than a long one, as it is stopped so much less. A slubber on .50-hank roving will make about eight doffs per day. Fifteen minutes per set, or two hours per day, are allowed for stoppages. We know of a

28-spindle slubber that requires only five minutes per set for stoppages, and thus produces 15 per cent more than the longer machine. While speaking of slubbers, it may be said that it is a very poor plan to have the cans running empty at random. A much better plan is to have one-third or one-fourth run out together. The attendant can then replace them and have more time for other duties than if he were continually looking for ends to run out. Roving frames are now made so that they will stop when so many yards have been run. The tender on the next machine can then creel a whole row at the same time, and not be continually piecing up short ends as at present, or wasting a great deal in creeling, as is allowed in some mills. It is the custom in New England to have doffers in the card-room just as in the spinning-room, and where there is enough work to keep them busy, there is no question about the economy of having them.

The weight of frames vary so much that we will not attempt to give any schedule. English frames are heavier than American, and the Providence frame lighter than others on account of the absence of the carriage weights, which the balanced carriage dispenses with. When English frames are used, there is no use of paying freight, and 45 per cent duty on the weights, as they are just as cheap here. The roller and other weights average about 2,000 pounds per frame.

The length of frames may be found by multiplying the space by one-half the number of spindles and adding 3 feet for gearing. The width is 3 feet. If the balanced carriage is used, 1′-4″ should be added to the length. English frames are sometimes built with gearing at both ends. In this case, 1′-10″ should be added. Three sets of change gears, and 5 per cent of spare rollers are furnished without extra charge. English builders do not furnish so many spare rollers, but furnish duplicates of the parts which are the most likely to be broken.

All speeders, and for that matter other machinery, should be carefully lined up after being run about a year. By this time the walls have settled and the floor timbers sprung about all they ever will. The frame will then run a number of years without further attention.

For the slubber, intermediate, fine frame and jack, about 50, 60, 75 and 100 spindles will absorb a horse power.

CHAPTER V.

Ring Spinning.

In the processes just described the useful action of the machine was simply drawing the sliver finer and making it even. Cleaning, evening and assorting the long fibers belong to processes preceding the roving frame. Cleaning, however, is a continuous process, and does not stop even at the loom. We now come to the processes by which the finished yarn is made from the roving. This is done by three methods, viz., mule, ring and throstle spinning. The latter is very rarely found in this country, and is being quickly superceded in England. There is no question as to the superior quality of yarn spun on this machine, but it is too slow for modern ideas. For practical purposes, the spinning is either done on the ring frame or on the mule. There are advantages in both methods, and for certain purposes one machine is better than the other. In England, the spinning frame is not so universally used as in this country. The reason is probably due to a great extent to their system of manufacture. The carding and spinning is done in one mill, and the weaving, or manufacturing as they call it, in another, often in a distant part of the country. It becomes inconvenient to ship

bobbins back and forth, but as a cop is spun on a small paper tube, the shipping of cops does not amount to much.

As is said above, many things might be said in favor of both methods. For the spinning frame it may be said that it occupies less space than a mule, that it gives a larger production, that it costs much less to operate, and that it can be operated by women and children. In New England, a reason apart from all these that has caused many mules to be replaced by spinning frames, is a well-organized, and at times arbitrary, union among mule spinners.

Taking these causes somewhat in detail, we find that two mules having 500 spindles each would occupy a space $88' \times 20' = 1,760$ square feet, or 1.76 square feet per spindle. Four spinning frames of 250 spindles each would occupy a space, counting alleys, of 800 square feet, or .80 square feet per spindle—only 45 per cent as much as a mule. In the matter of production, a mule on number 30's will produce .2 pounds per day per spindle. A spinning frame will produce .216 pounds per day, a gain of 8 per cent. For spinning 30's on a mule, the spinner will have to be paid from $1.50 to $2.00 per day, against $1.00 on the spinning frame, a difference of 50 to 100 per cent. For fine yarns, this difference is not so great.

On the other hand, a mule consumes a horse-

power for 160 spindles, against 75 for a spinning frame, a gain of over 100 per cent. The cost of supplies will be slightly in favor of the mule, as there are no travellers or bobbins. Mules cost about $2.70 per spindle, against $3.00 for spinning frames, another advantage in favor of the mule. However, the chief item in its favor is that a mule is absolutely necessary for spinning very fine yarns, and that for soft yarn it produces much better thread than the spinning frame. On the whole, the verdict seems to be in favor of the spinning frame, and within the past ten years many thousand mule spindles have been replaced by frame spindles.

In a spinning frame, the roving is drawn out from 6 to 15 times its length by three lines of rollers exactly as in roving frames. The twist is put in by revolving spindles as in a roving frame, but the winding is altogether different. It could be done in the same manner, and the fact that the process is similar is shown by the fact that coarse yarn is sometimes made on a roving frame. This was largely done some years ago when the Southern farmers, to break up the bagging trust, used covering for their cotton woven from coarse yarn, in many cases made on a roving frame.

Many pages might be written concerning the use of the traveller, but we will assume that the reader is sufficiently familiar with its action to

readily understand its use. There is still an erroneous idea in the minds of some that the traveller puts in the twist. The fact that this is not true is clearly shown by the mule where there is no traveller. If anything, the traveller retards the twisting.

After evenness, the next essential of good yarn is strength. This is accomplished by twisting, which is done in two ways, the intermittent as in the mule, and the continuous as in the spinning frame. Each is superior for certain purposes. On the mule, a strand of roving is delivered to the spindles, which gradually recede from the rollers, twist being put in while this is being done. The velocity at which the spindles recede is a little greater than the delivery of the rollers, creating a distance draft, which always runs to the thin places and leaves the thick ones untwisted, or at least this would be the case if there were no carriage draft. Owing to this, the soft places where there is no twist and no strength, are drawn out and an even thread is produced. This gain is only used in spinning fine numbers. For very coarse numbers, the gain is the other way. The end of the stretch is reached a little before the spindles have ceased to rotate, so that after the yarn is evened a certain amount of twist is put in, which is evenly distributed to every part of the yarn. On the spinning frame, the thin places remain as they

come from the roller, but receive a proportionate amount of the twist, and consequently strength is put in where it is most needed. For this reason frame-spun yarn is usually a little stronger than mule spun.

In England the mule is still recognized as the standard spinning machine. Fifteen or twenty years ago its use was almost universal in New England, and to-day there are many thousand spindles in Lowell, New Bedford and Fall River, though in the latter city a large number have been replaced by ring frames. In the South, about a dozen mills out of over 500 have mules, no one mill having over 15,000 or 20,000 spindles.

CALCULATIONS.

As in the roving frames, the principal calculations are for twist, draft and production. As in roving, the twist in yarn is based on the square root of the number. Even with this basis there are several multipliers, depending on the use for which the yarn is intended, and also depending on the machine on which it is made. Thus 4.75 times the square root is standard twist for warp when spun on the ring frame, 3.75 if spun on the mule, 3.25 for filling on the mule, 3.50 for filling on frames, 2.75 for yarn to be twisted and 2.50 for mule-spun hosiery yarn. It will be readily seen that the system is somewhat complex. Within the past few years there

has been a difference recognized between the twist for mules and for ring frames. This difference has existed all the time in practice, but each machine builder hesitated to publish a table giving more twist, and consequently lower speed, than others, and many mill men have been discouraged and lost their positions because they were not able to make the frames run at the twist and speed given in catalogues.

We give below a table for twist on the new basis.

TWIST TABLES.

Counts or Numbers.	Frame Warp Twist.	Frame Filling Twist.	Mule Filling Twist.	Twist for Doubling.	Hosiery Yarn.
1	4.75	3.50	3.25	2.75	2.50
2	6.72	4.95	4.60	3.89	3.53
3	8.23	6.06	5.63	4.76	4.33
4	9.50	7.00	6.50	5.50	5.00
5	10.62	7.83	7.27	6.15	5.59
6	11.63	8.57	7.96	6.73	6.12
7	12.56	9.26	8.60	7.27	6.61
8	13.43	9.90	9.19	7.78	7.07
9	14.25	10.50	9.75	8.25	7.50
10	15.02	11.07	10.27	8.69	7.90
11	15.75	11.61	10.78	9.12	8.29
12	16.45	12.12	11.26	9.52	8.66
13	17.12	12.62	11.72	9.91	9.01
14	17.77	13.10	12.16	10.29	9.35
15	18.39	13.56	12.59	10.65	9.68
16	19.00	14.00	13.00	11.00	10.00
17	19.58	14.43	13.40	11.34	10.31
18	20.15	14.85	13.79	11.66	10.60
19	20.70	15.26	14.17	11.98	10.89
20	21.24	15.65	14.53	12.30	11.18
21	21.76	16.04	14.89	12.60	11.46
22	22.27	16.42	15.24	12.89	11.73

TWIST TABLES—*Continued.*

Counts or Numbers.	Frame Warp Twist.	Frame Filling Twist.	Mule Filling Twist.	Twist for Doubling.	Hosiery Yarn.
23	22.78	16.79	15.59	13.19	11.99
24	23.27	17.15	15.92	13.47	12.25
25	23.75	17.50	16.25	13.75	12.50
26	24.22	17.85	16.57	14.02	12.75
27	24.68	18.19	16.89	14.29	12.99
28	25.13	18.52	17.20	14.55	13.23
29	25.58	18.85	17.50	14.81	13.46
30	26.02	19.17	17.80	15.06	13.69
31	26.44	19.49	18.10	15.31	13.92
32	26.87	19.80	18.38	15.55	14.14
33	27,28	20.11	18.67	15.80	14.36
34	27.69	20.41	18.95	16.03	14.58
35	28.10	20.71	19.23	16.27	14.79
36	28.50	21.00	19.50	16.50	15.00
37	28.89	21.29	19.77	16.72	15.21
38	29.28	21.58	20.03	16.95	15.41
39	29.66	21.86	20.30	17.17	15.61
40	30.04	22.14	20.55	17.39	15.81
41	30.42	22.41	20.81	17.61	16.01
42	30.78	22.68	21.06	17.82	16.20
43	31.14	22.95	21.31	18.03	16.39
44	31.50	23.22	21.56	18.24	16.58
45	31.86	23.48	21.80	18.45	16.77
46	32.21	23.74	22.04	18.65	16.96
47	32.56	23.99	22.28	18.85	17.14
48	32.90	24.25	22.52	19.05	17.32
49	33.25	24.50	22.75	19.25	17.50
50	33.58	24.75	22.98	19.44	17.68
51	33.92	24.99	23.21	19.64	17.85
52	34.25	25.24	23.44	19.83	18.03
53	34.58	25.48	23.66	20.02	18.20
54	34.90	25.72	23.88	20.21	18.37
55	35.22	25.96	24.10	20.39	18.54
56	35.54	26.17	24.32	20.58	18.71
57	35.86	26.42	24.53	20.76	18.87
58	36.17	26.66	24.75	20.94	19.04
59	36.48	26.88	24.96	21.12	19.20
60	36.79	27.11	25.16	21.30	19.36

The calculation for twist is as follows:

Rule.—*Consider the whirl the driver. Multiply the diameter of the whirl by all the driving gears and the circumference of the front roller, and divide the product into the diameter of the cylinder, multiplied by all the driven gears.*

If the whirl is $\frac{3}{4}''$, consider it 3, and also put the diameter of the cylinder in fourths. If it is $7''$, put it 28. If the whirl is $\frac{7}{8}''$, use 7 in the calculation, and 56 for the cylinder.

Example.—Cylinder $7''$, whirl $\frac{3}{4}''$, cylinder gear 25 teeth, stud or crown gear 100 teeth, twist gear 56 teeth, front-rollers gear 112 teeth, what is the twist, with 10 per cent allowance?

$$\frac{28 \times 100 \times 112}{3 \times 25 \times 56 \times 3.14} = 23.77$$

23.77 less 10 per cent, = 21.40.

As in other calculations, the twist multiplied by the twist gear equals the twist constant.

The best way to ascertain the twist is to mark a bobbin and count the number of turns it makes while the front roller revolves one time. Divide the number by 3.1416, and the quotient is the actual twist per inch. When calculating the twist, allowance must be made for slippage of bands, and for size of bands. It is obvious that a band fitting in a V-shaped groove will turn the whirl where the greatest pressure is. This is not at the bottom of the groove, but somewhere between it and its greatest working diameter.

No two builders agree concerning this loss of twist. Some put it at 8 per cent, some at 10, and some at 13. In the tables this allowance is usually made in stating the relation of the cylinder to the whirl. If the calculations are made by gears, this difference complicates matters, but if made by the above method, the results are actual. It has long been known by good spinners that small bands were better than large ones, one of the chief reasons being that they give more twist, as their effective diameter is nearer the bottom of the groove.

TABLE OF TWIST CONSTANTS. MASON FRAME.

Diam. of Whirl.	Diam. of Cyl.	Relation.	Cylinder. Gear.	Crown Gear.	Front Roller Gear.	Cir. of Roller.	Constant.
13—16	7	7.75	18	92	112	3.1416	1342.20
13—16	7	7.75	24	90	112	3.1416	984.30
13—16	7	7.75	30	90	112	3.1416	787.20
13—16	7	7.75	36	84	112	3.1416	612.60
13—16	7	7.75	52	68	112	3.1416	343 20
3— 4	7	8.125	18	100	112	3.1416	1529.10
3— 4	7	8.125	18	130	84	3.1416	1490.70
3— 4	7	8.125	18	92	112	3.1416	1407.30
3— 4	7	8.125	24	90	112	3.1146	1032.30
3— 4	7	6.125	30	00	112	3.1416	825.90
3— 4	7	8.125	35	70	112	3.1416	550.00
7— 8	7	7.	36	84	112	3.1416	553.20

5 per cent is allowed for slippage and 13 per cent for size of bands.

Constant ÷ Twist=Twist Gear.

TABLE OF TWIST CONSTANTS. HOWARD & BULLOUGH FRAME.

Diam. of Whirl.	Diam. of Cylin.	Rela- tion.	Cylin. Gear.	Jack Gear.	Front Roller Gear.	Con- stant.
3— 4	7	8.14	21	86	84	891.63
3— 4	7	8.14	21	96	84	995.31
3— 4	7	8.14	21	106	84	1098.98
3— 4	7	8.14	17	106	84	1357.57
13—16	7	7.60	29	72	84	504.51
13—16	7	7.60	21	76	84	735.42
13—16	7	7.60	21	86	84	832.18
13—16	7	7.60	17	72	84	860.64
13—16	7	7.60	21	96	84	928.95
13—16	7	7.60	21	106	84	1025.71
13—16	7	7.60	17	86	84	1027.99
13—16	7	7.60	17	106	84	1267.06
7— 8	7	7.12	39	72	84	351.70
7— 8	7	7.12	29	72	84	472.98
7— 8	7	7.12	21	72	84	653.17

5 per cent is allowed for slippage and 8 per cent for size of bands.

Constant ÷ Twist = Twist Gear.

TABLE OF TWIST CONSTANTS. SACO-PETTEE FRAME.

Diam. of Whirl.	Diam. of Cyl.	Rela- tion.	Cylind'r Gear.	Jack Gear.	Front R. Gear.	Constant
3—4	7	8.25	38	124	108	926
3—4	7	8.25	30	132	65	751
13—16	7	7.75	38	124	108	870
13—16	7	7.75	30	132	65	706
7—8	7	7.25	38	124	108	814
7—8	7	7.25	30	132	65	660
3—4	7	8.25	38	124	94	806
3—4	7	8.25	30	132	108	1249
13—16	7	7.75	38	124	94	757
13—16	7	7.75	30	132	108	1173
7—8	7	7.25	38	124	94	708
7—8	7	7.25	30	132	108	1097
3—4	7	8.25	54	108	65	342
13—16	7	7.75	54	108	65	321
7—8	7	7.25	54	108	65	300

No allowance for slippage, and 10 per cent for size of bands.

Constant ÷ Twist = Twist Gear.

TABLE OF TWIST CONSTANTS. WHITIN FRAME.

Diam. of Whirl.	Diam. of Cyl.	Relation.	Cylind'r Gear.	Stud Gear.	F. Roller Gear.	Constant
3—4	6.25	7.44	22	88	108	1022.70
3—4	6.25	7.44	36	74	108	525.60
7—8	6.25	6.47	22	88	108	889.20
7—8	6.25	6.47	36	74	108	456.90
3—4	6.25	7.44	55	55	108	255.60
7—8	6.25	6.47	55	55	108	222.30
3—4	7	8.33	55	55	108	286.20
3—4	7	8.33	22	88	108	1145.10
3—4	7	8.33	36	74	108	588.30
7—8	7	7.25	22	88	108	996.60
7—8	7	7 25	36	74	108	512.10
13—16	7	7.68	22	88	108	1055.70
13—16	7	7.68	36	74	108	542.40
13—16	7	7.68	55	55	108	264.00
7—8	7	7.25	55	55	108	249.00
3—4	8	9.52	55	55	108	327.00
7—8	8	8.28	55	55	108	284.40
3—4	8	9.52	22	88	108	1308.60
3—4	8	9.52	36	74	108	672.40
7—8	8	8.28	22	88	108	1138.20
7—8	8	8.28	36	74	108	584.70
13—16	8	8.91	22	88	108	1224.60
13—16	8	8.91	36	74	108	629.40
13—16	8	8.91	55	55	108	306.30

No allowance for slippage, and 10 per cent for size of bands.
Constant ÷ Twist = Twist Gear.

TABLE OF TWIST CONSTANTS. LOWELL FRAME.

Diam. of Whirl.	Gear on Cylin.	Stud Gear.	Front Roller Gear.	Constant $6\frac{1}{4}$ Inch Cylin.	Constant 7 Inch Cylin.	Constant 8 Inch Cylin-
3—4	24	91	91	801.60	891.8	1011.3
13—16	24	91	91	749.40	824.4	948.9
7—8	24	91	91	702.80	773.6	889.5
3—4	30	85	91	599.00	666.2	755.7
13—16	30	85	91	560.40	621.4	708.9
7—8	30	85	91	525.20	578.4	664.5
3—4	40	75	91	396.40	440.8	500.1
13—16	40	75	91	370 80	411.6	469.2
7—8	40	75	91	347.40	382.8	439.8
3—4	50	120	91	507.60	564.6	....
13—16	50	120	91	475.00	527.2	....
7—8	50	120	91	445.00	490.2	....
3—4	63	108	91	362.60	403.4	....
13—16	63	108	91	339.20	376.4	....
7—8	63	108	91	315.40	350.2	....
3—4	91	80	91	185.60	206.8	....
13—16	91	80	91	174.00	193 0	....
7—8	91	80	91	163 00	179.6	....
3—4	24	91	80	....	784.0	....
19—16	24	91	80	....	731.8	....
7—8	24	91	80	....	680.6	....
3—4	30	85	80	....	585.8	....
13—16	30	85	80	....	546.8	....
7—8	30	85	80	....	508 6	....
3—4	40	75	80	....	387.6	....
18—16	40	75	80	....	361.8	....
7—8	40	75	80	....	336.6	....

No allowance for slippage, and 9 per cent for size of bands.
Constant ÷ Twist=Twist Gear.

Draft.—For calculating the draft of a spinning frame, the rule is the same as for other machines, viz.:

Rule.—*Consider the back roller the driver; multiply the diameter of the front roller and all the driving gears together for a numerator; multiply the diameter of the back roller, and the*

driven gears for a denominator. The quotient will be the draft.

Example.—Diameter of front roller, 1″ or 8—8. Diameter of back roller $\frac{7}{8}$. Crown gear 80. Front roller gear 30. Back roller gear 74. Draft gear 25.

$$\frac{8 \times 80 \times 74}{7 \times 30 \times 25} = 9.04$$

9.04×25 (Draft gear) $= 226. =$ Constant.

TABLE OF DRAFT CONSTANTS. MASON FRAME.

Diam. F. Roller.	Diam. B. Roller.	F. Roller Gear.	Crown Gear.	B. Roller Gear.	Constant.
1	$\frac{7}{8}$	30	140	84	447.90
1	$\frac{7}{8}$	30	128	84	409.50
1	$\frac{7}{8}$	30	116	84	371.10
1	$\frac{7}{8}$	30	84	84	268.80
1	$\frac{7}{8}$	30	78	84	207.90

Constant $\div$ Draft $=$ Draft Gear.

TABLE OF DRAFT CONSTANTS. WHITIN FRAME.

Diam. F. Roller.	Diam. B. Roller.	F. Roller Gear.	Stud Gear.	B. Roller Gear.	Constant.
1	$\frac{7}{8}$	28	84	84	288.0
1	$\frac{7}{8}$	30	84	84	268.8
1	$\frac{7}{8}$	30	168	84	537.6
1	$\frac{7}{8}$	30	60	84	192.0
1	$\frac{7}{8}$	30	120	84	384.0

Constant $\div$ Draft $=$ Draft Gear.

TABLE OF DRAFT CONSTANTS. SACO-PETTEE FRAME.

Diam. F. Roller.	Diam. B. Roller.	F. Roller Gear.	Stud Gear.	B. Roller Gear.	Constant.
1	$\frac{7}{8}$	25	70	84	268.8
1	$\frac{7}{8}$	16	79	84	474.0

Constant $\div$ Draft $=$ Draft Gear.

TABLE OF DRAFT CONSTANTS. HOWARD & BULLOUGH FRAME.

Diam. F. Roller.	Diam. B. Roller.	F. Roller Gear.	Crown Gear.	B. Roller Gear.	Constant.
1	$\frac{7}{8}$	27	72	89	271.23
1	$\frac{7}{8}$	27	90	79	300.95
1	$\frac{7}{8}$	27	90	89	339.04
1	$\frac{7}{8}$	21	72	89	348.73
1	$\frac{7}{8}$	27	108	89	406.85
1	$\frac{7}{8}$	21	90	89	435.91
1	$\frac{7}{8}$	21	108	89	523.10

Constant ÷ Draft = Draft Gear.

TABLE OF DRAFT CONSTANTS. LOWELL FRAME.

Front Roller Gear.	Stud Gear.	Back Roller Gear.	Middle Roller Gear.	Constant.
20	70	50	....	200.
20	70	54	....	216.
20	70	55	....	220.
20	70	56	....	224.
30	104	75	....	297.
30	104	79	....	312.9
30	104	84	....	332.7
20	64	50	....	182.8
20	64	54	....	197.4
20	64	55	....	201.
20	64	56	....	205.8
20	64	58	....	210.2
Geared at both ends.				
14	15 and 35	21	20	5.00
14	15 and 30	21	20	5.833
14	15 and 25	21	20	7.005

New style, Constant ÷ Draft = Draft Gear.
Old style, Constant × Draft = Draft Gear.

Production.—The production of a spinning frame is calculated from the front roller just as for a roving frame.

Rule.—*Multiply the circumference of the front roller by its speed per minute, number of minutes in an hour, and number of hours per day, and divide by 840 multiplied by 36 and the number of yarn.*

Example.—A frame on number 30's has a front roller speed of 115 turns per minute. What is the production per spindle in 11 hours?

$$\frac{3.14 \times 115 \times 60 \times 11}{840 \times 36 \times 30} = .262 \text{ pounds.}$$

A deduction of 10 per cent is usually made for doffing, cleaning, etc.

All machine builders give in their catalogues a table for production for both warp and filling. It is the opinion of the writer that these tables are too high, especially for filling. While we know that under the most favorable conditions these figures are attained, we are confident that a large majority of the mills fall far short. It is true that many mills claim to be getting 90 per cent production, but when these claims are investigated, it is often found that they are based, not on the speed at which the front roller is supposed to run, but on the speed it is running. In other words, the spinner has put in sufficient twist to make the work run perhaps unusually well, and then bases his production on the reduced speed. For many years the writer made it a point to get the published pro-

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duction. This was done by giving the spinners not more than six sides, and keeping them hard at work. For a number of years it has become more and more difficult to keep good spinners, and where it is necessary for them to keep constantly at work to keep their ends up, they have to be paid more, and even then the mill will often lose more in a week on account of frames being stopped, than it would lose in a year by keeping them running at a slightly reduced speed.

As we said above, the over-estimation of production is especially true on filling frames. Spinning frames in England are used for warp, and for filling mules are used almost exclusively. The standard twist for mule-spun filling is 3.25 times the square root of the number, and until the last few years this was still published as the standard for frame-spun filling. As a matter of fact, it is wholly impracticable to run filling frames at this twist, and at the speed usually called for. If it is necessary for the filling to be very soft, the speed of the frame should be reduced, and if it is not necessary, the twist should be increased. In the following table for filling yarn we have calculated the twist at 3.50 times the square root of the number, and have reduced the speed about 10 per cent from that usually given. It is better and cheaper for the manufacturer to buy a few more machines than to have over-worked or over-paid spinners.

In the table for filling yarns the twist is figured at 3.50 times the square root of the number up to No. 30's. After this number, on account of longer cotton being used, the twist is gradually reduced until at No. 100's it is only 3.09 times the square root.

PRODUCTION OF RING-WARP YARN, 10 HOURS.

No. of Yarn.	Twist, Per Inch.	Rev. of Roller.	Rev. of Spindles.	Lbs. Per Day.	No. of Yarn.	Twist Per Inch.	Rev. of Roller	Rev. of Spindles.	Lbs. Per Day.
4	9.50	154	4600	2.160	33	27.28	110	9500	.195
5	10.62	152	5100	1.715	34	27.69	109	9500	.186
6	11.63	150	5500	1.407	35	28.10	107	9500	.180
7	12.56	149	5900	1.198	36	28.50	106	9500	.173
8	13.43	148	6300	1.051	37	28.89	104	9500	.166
9	14.25	147	6600	.919	38	29.28	103	9500	.159
10	15.02	146	6900	.829	39	29.66	101	9500	.153
11	15.75	143	7100	.740	40	30.04	100	9500	.147
12	16.45	142	7400	.685	41	30.42	99	9500	.142
13	17.12	141	7600	.623	42	30.78	98	9500	.137
14	17.77	139	7800	.572	43	31.14	97	9500	.132
15	18.39	138	8000	.529	44	31.50	96	9500	.128
16	19.00	137	8200	.492	45	31.86	94	9500	.125
17	19.58	134	8300	.455	46	32.21	93	9500	.121
18	20.15	133	8500	.428	47	32.56	92	9500	.117
19	20.70	132	8600	.399	48	32.90	91	9500	.113
20	21.24	131	8800	.378	49	33.25	90	9500	.110
21	21.76	130	8900	.355	50	33.58	90	9600	.108
22	22.27	128	9000	.335	55	35.22	86	9600	.0943
23	22.78	125	9000	.314	60	36.79	84	9800	.0845
24	23.27	124	9100	.298	65	38.30	81	9800	.0750
25	23.75	123	9200	.283	70	39.74	77	9700	.0665
26	24.22	122	9300	.272	75	41.14	74	9600	.0592
27	24.68	119	9300	.258	80	42.78	70	9400	.0527
28	25.13	117	9300	.244	85	43.79	66	9200	.0471
29	25.58	116	9400	.233	90	45.06	63	9000	.0427
30	26.02	115	9400	.223	95	46.30	60	8800	.0385
31	26.44	113	9400	.212	100	47.50	57	8600	.0352
32	26.87	112	9500	.205					

PRODUCTION TABLE OF RING-FILLING YARN, 10 HOURS.

No. of Yarn.	Twist Per Inch.	Rev. of Front Roller	Rev. of Spindles.	Lbs. Per Day.	No. of Yarn.	Twist Per Inch.	Rev. of Front Roller	Rev. of Spindles.	Lbs. Per Day.
4	7.00	164	3600	2.173	33	18.99	120	7100	.207
5	7.83	161	4050	1.708	34	19.05	119	7100	.200
6	8.57	160	4325	1.435	35	19.23	118	7100	.193
7	9.26	159	4625	1.221	36	19.50	116	7100	.186
8	9.90	157	4900	1.059	37	19.77	114	7100	.175
9	10.50	155	5125	.927	38	20.03	113	7100	.171
10	11.07	154	5350	.836	39	20.30	111	7100	.162
11	11.61	152	5525	.750	40	20.55	110	7100	.160
12	12.12	150	5700	.687	41	20.81	109	7100	.154
13	12.62	148	5850	.624	42	21.06	108	7100	.149
14	13.10	146	6025	.575	43	21.31	107	7100	.144
15	13.56	145	6175	.530	44	21.56	106	7100	.139
16	14.00	143	6250	.488	45	21.80	104	7100	.135
17	14.43	141	6400	.456	46	22.04	103	7100	.130
18	14.85	139	6475	.424	47	22.28	102	7100	.126
19	15.26	137	6575	.397	48	22.52	100	7100	.122
20	15.65	135	6650	.377	49	22.75	99	7100	.118
21	16.04	134	6750	.355	50	22.98	98	7100	.116
22	16.42	133	6850	.335	55	24.10	94	7100	.101
23	16.79	131	6925	.317	60	25.66	90	7100	.090
24	17.15	130	7025	.302	65	25.79	87	7025	.080
25	17.50	129	7075	.286	70	26.75	84	7025	.072
26	17.81	128	7075	.272	75	27.71	81	7025	.065
27	18.16	127	7075	.262	80	28.16	78	6925	.060
28	18.51	126	7100	.250	85	29.04	75	6825	.054
29	18.83	125	7100	.236	90	29.39	72	6650	.049
30	18.89	124	7100	.230	95	30.19	70	6650	.045
31	18.92	123	7100	.226	100	30.50	68	6575	.042
32	18.94	122	7100	.219					

Strength of Yarn.—At the Atlanta, Ga., Textile School elaborate tests were recently made on many samples of yarn, varying the twist on either side of the standard. The result showed conclusively that yarn is strongest with the standard twist. If more than standard is put in, except in very short cotton, the yarn is not strengthened but weakened.

The following table, which is considered the standard, is taken from Draper's Catalogue, and shows the result obtained by testing samples from 225 representative mills. There is also what is known as an English standard, but it is so elastic and unreliable that we do not publish it.

BREAKING STRENGTH OF WARP YARN.

1	....	15	115.1	29	59.2	43	42.2	57	33.4
2	....	16	108.4	30	57.3	44	41.4	58	32.8
3	530.0	17	102.5	31	55.6	45	40.7	59	32.3
4	410.0	18	97.3	32	54.0	46	40.0	60	31.7
5	330.0	19	92.6	33	52 6	47	39.3	61	31.3
6	275 0	20	88.3	34	51.2	48	38 6	62	30.8
7	237.6	21	83.8	35	50.0	49	37.9	63	30.4
8	209.0	22	79.7	36	48.7	50	37.3	64	30.0
9	186.5	23	75.9	37	47.6	51	36.6	65	29.6
10	168.7	24	72.4	38	46.5	52	36.1	66	29.2
11	154.1	25	69.2	39	45.5	53	35.5	67	28.8
12	142.0	26	66.3	40	44.6	54	34.9	68	28.5
13	131.5	27	63.6	41	43.8	55	34.4	69	28.2
14	122.8	28	61.3	42	43.0	56	33.8	70	27.8

TROUBLES IN THE SPINNING ROOM.

Weak Yarn.—There is only one trouble that is more frequent than this, and that is the general one of bad-running work. Weak yarn may result from weak cotton. In America, we handle very little except American cotton, and the strength of the many varieties is not studied as closely as it is in England. However, it is no unusual thing to find a mill spinning yarn that is too fine for the cotton used. It is absurd to expect number 40's made from ordinary cotton to break at the standard weight. For warp yarn we think the limit has been reached when 30's is made from ordinary

upland cotton. For many purposes, strength is not essential, and we know of number 42's filling being successfully spun from South Carolina cotton. Of course it is customary for the spinner to blame the carder for uneven roving, and what is written under that head is largely applicable here. Even with good roving it is very easy to make weak yarn.

Excessive Draft.—For warp yarn, we do not think that the draft should exceed 12, or at most 13. We are of course aware that this draft is often exceeded, but for the best results we should confine it to this limit. For filling, where strength is not so essential, 14 and even higher may be drawn. This is assuming that the roving is double. With single roving the draft should be less than 10. A few years ago it was a common argument among spinners as to which were the more desirable, single or double roving. We now hear very little about it, and it is almost universally conceded that it is much better to have it double, although it will cost more. This does not apply to coarse yarns, for they are sufficiently strong to stand high speed and need no special doubling to increase their strength.

Excessive Speed.—We have spoken of this at some length on a previous page, and will only add that it not only keeps the spinners working harder, but also by undue chafing against the traveller and separator, weakens the yarn. In

mills where they make sewing thread the ideas of speed are very conservative.

Worn travellers also have a bad effect on the yarn. This is especially true where the yarn is rather coarse. On fine yarn, the travellers break just as soon as they are worn, and consequently need but little attention. On medium or coarse work, the travellers should be changed at regular intervals. For ordinary numbers, this should be done every three weeks. The spinners should not be expected to do this, as they have neither the time nor the judgment necessary. When it is done it should be under the supervision of a competent man. Many rings have been ruined by breaking off the travellers with the top roller.

In general terms, it may be said that anything that tends to make the work run bad will weaken the yarn, for the cause which makes the end break will not break it every time, but will weaken it many times when it does not break. When it does break, and is pieced up by the spinner, it is seldom as strong at the splice as it is at other points. Assuming that the roving is good, we believe that the most prolific source of bad running work is the top rollers. They may be either worn, fluted, dry, or choked with waste. It is true that it costs something to cover rollers, but it is no economy to use one after it has caused an end to break. The steel rollers should be frequently oiled. They run at such different speeds that

it is impossible to give a rule which will apply to all conditions. The ends of the top rollers need not be oiled, after the frame has been run a few months, except when a new one has been put on. They need but little oil, and get that when the spinner is cleaning them with oily fingers. The saddles should be oiled either with the well-known tin tube and sponge, or with a Thompson can with a very small opening. We are sure a great many rollers are spoiled, and a great deal of bad work results from the careless use of oil. The rollers should be cleaned twice daily. With modern frames, where the bearings extend above the cap bar, they are much easier to keep clean than formerly. The spindles should be oiled every two weeks. If we were sure they were all oiled, once a month would be sufficient, but for fear some are neglected it is best to be on the safe side. This is an unpleasant job, and it is a good plan to have a box put on rollers, so that the boys can sit down and roll the box along as they oil. They will then be comfortable, and not near so apt to neglect the work.

We believe that a large proportion of spindles are improperly set. The machine erectors usually run the ring-rail half up and set the spindles in the center. This is not the proper way. They should first be set when the rail is near the bottom. It should then run to the top, and if the spindle is not in the center, it is proof that it is

not plumb, and should be papered up. After this it should be again run down and see if the rings are still in the center. Spindles and rings should be set once a year without fail.

Slack bands make a great of trouble for the spinner, as well as for the weaver. Roving bands do not stretch as much as yarn bands, and are much better. The second hand or overseer should go over the bands occasionally and see if they are too loose. They need attention especially after several days of very damp weather, which draws them tight, and when they dry out many are too slack.

A worn guide, or one that is not over the center of the spindle, will make bad work. They should be set while the spindle is running, as modern spindles are in a slightly different position when running and when standing. It is well to notice the spindles carefully. One which vibrates is apt to cause trouble. The step may need adjusting, the bolster may be broken, or the spindle itself bent. A bad ring may be used for some time, especially on coarse work, but it will soon ruin enough travellers to pay for another one. Besides this, every time a traveller breaks some waste is made, and a weak place is made in the yarn. Rings should be cleaned occasionally. Some overseers claim that the traveller bears only on a very small part of the ring, and the traveller itself will keep it clean. This

is a mistake, and for thorough cleaning the rails should be put into a box of concentrated lye. If practicable, let them remain in the bath all night. They should then be rinsed in hot water, after which they will dry in a few minutes.

Cut Yarn.—This might be classed under the head of uneven yarn, as the terms are almost synonymous. If it is not known on which frame the yarn is spun, examine all draft gears, as one or more teeth may be broken out. Sometimes the gears are not set deep enough, and slip a tooth occasionally. Where the gears are worn, they are likely to be put too deep in gear, which causes the rolls to jump or vibrate. On old frames the squares in the end of roller may be worn so as to slip occasionally. This is only on back rollers, for if it occurs on the front roller, the trouble will be apparent at once. A piece of traveller or part of a broken tooth may accidentally, or purposely, find its way between the teeth of the draft gears, causing the roller to jump at that point.

Bunchy or Lumpy Yarn.—This may be caused by bad piecing. Either the scavenger rollers or the clearer boards may get too full, and the waste drop down on the roving. This is especially likely to happen when spinning long cotton, as the rollers are then farther apart. The frames should be stopped while the ceiling is being brushed down. In many mills the frames are

covered while this is done. Weight hooks resting on the back boards will make bunchy yarn. Occasionally a front roller is crooked. This will make a thick and a thin place at every revolution. A great deal of lumpy yarn is made by spinners when wiping off the thread board. This seems to be a necessary evil, but careful spinners will greatly diminish it. They should not be allowed to fan off with their aprons or to blow off the lint through a bobbin.

Spiral or Corkscrew Yarn.—See this treated under twisters.

Ends Running Bad.—A spinner may observe all the foregoing points, and yet the ends run bad. What, then, is to be done? The numbers may be too light; size 16 or more bobbins per day of each kind of yarn; have the carder give you each day 8 roving bobbins, and size the yarn from these in addition to the bobbins taken at random. This will enable the spinner to know what to expect, and a careful record should be kept of these numbers. Do not jump at conclusions because one set of bobbins is light. Weigh a large number before changing the draft gear, but if too much is light or heavy, do not hesitate to make a change. There is a foolish idea in some mills that all changes of this character should be made in the card-room.

There may be insufficient moisture in the room, or electricity may be giving trouble. Warming

the air and getting it moist will stop this difficulty. If there are no air moisteners, a sprinkler will do a great deal of good. Spinners must bear in mind that warm air will hold in suspension much more moisture than cold air.

Bad work may be caused by a bale or several bales of unusually short or bad cotton. Find out how much of this there is. If there is only a little, a few extra hands will enable the room to pull through. If there is a good deal, put in more twist or reduce the speed, or both. If it is a spinning mill only, the speed may be easily reduced at the engine.

Cockley Yarn.—In a very general way it may be said that long-staple cotton is the cause of this, although it is not always so. There are some varieties of cotton more harsh and wirey than others, and consequently more difficult to draw. Sometimes roving being twisted too hard will cause it. We know of a mill where the spinning was running unusually bad when a new overseer took charge. Investigation showed that the speeders were running unusually well, and further investigation showed that the roving was twisted too hard. The old spinner had trouble with cockley yarn, and had spread the rollers one-eight inch in order to remedy it. The extra twist was taken from the roving, the rollers closed up, and the spinning ran fifty per cent better.

By far the most frequent cause of cockley yarn is that there are just a few long fibers in a cross section of roving. One end of these fibers is held by the middle roller, while the other end is beyond the bite of the front roller. The bobbin is consequently pulling the thread down as fast as it is delivered by the front roller, but the middle roller, having hold of these fibers, holds them back, and the other fibers, being delivered by the front rover, and not being taken care of by the bobbin, bend back on themselves and form a kink. If a piece of yarn having one of these kinks in it is carefully untwisted and the fibers examined, it will be readily seen where the trouble is. The remedy, however, is not so simple. It will at once occur to the average man that the rollers should be spread, and if this is done the trouble will disappear. But, as stated before, other troubles may take its place, and the next day, or the same the stock may be short, and the rollers too far apart. It may be said that cockley yarn occurs more frequently in yarns spun from staple cotton, that is cotton more than one inch long. A remedy which never fails, is to have the saddle for the front and back rollers only, no weight being on the middle roller. We know of a large mill which made the change after everything else had been tried and failed, and the results were all that could be desired. It may be said that the trouble only occurs on filling, but this is

only partially true. It does not occur so frequently on warp, because the warp is usually coarser, and the greater pull of the traveller pulls the kinks out as fast as made, and if it does not, the tension on the yarn in the spooler is likely to, and it is not noticed in the cloth. We know of one mill which for months kept several sets of looms weaving nothing but cockley filling, and every yard woven was sold as seconds.

Waste.—This is classed as a trouble in the spinning room, and perhaps an overseer is criticised on account of it more than for any other one thing. The trouble is not so much in making waste, for that is inevitable, but in taking care of it after it is made. Nothing discounts a spinner so much as to have his floor littered up with waste. It is hard to keep the spinners from throwing white waste on the floor, but there is no reason why they should not be trained to do so the same as they are trained to keep roving bobbins, top rollers, or any other material they handle. Not only is the habit untidy, and tends to make the spinner careless in other matters, but much of this waste becomes mixed with dirt and oil and is sold for a trifle. As sweepings it is worth about three-quarters of a cent, and as good cotton from 10 to 15 cents. The best way to keep it off the floor is to *insist* that the spinners have pockets in their aprons at least 8″ × 4″. If they do not have them, do not allow them

to work until they get them. By the time these pockets get full, they become somewhat in the way, and serve as a reminder that it is time to empty them. Where they empty them, also, has a bearing on the appearance of the floor. An excellent waste box is about 18″ high and made from 12″ boards set up on end. In the top is a round hole, $4\frac{1}{2}''$ in diameter. These boxes can be packed, and made to hold a great deal, and there need be no occasion for their running over.

However, with the most careful system, some good cotton will be swept up as waste. This is supposed to be carefully picked out and returned to the picker-room. As a matter of fact, it is often carelessly done, and the writer knows of a case in the past few months where over 500 pounds of good cotton was picked out of a few bales of sweepings. A good plan is to have the good waste picked out, but not have the sweepings put in the waste box until they are inspected by the second hand or overseer.

Spinners very often leave the room with their pockets full of waste. Some of this is scattered about the village, and much of it finds its way into pillows and quilts. About the best way to stop this is to have a man stationed at the outside door, and require every spinner whose pocket is not empty to go entirely back to the spinning-room. A very little of this has the desired effect.

The clearer waste should be kept separate from

the sweepings, as it is worth three or four times as much. Putting it into a box to itself will also tend to keep the floor clean. Just here it may be said that the waste from the dust rolls of the cards can be put with the clearer waste. It is the same kind of stock, and is worth as much.

Bobbins Wound Too Low.—This trouble might be appropriately classed under the head of "Waste," for it is certainly a fruitful source of it. Not only is the yarn on the bobbin frequently wasted, but the groove by which the bobbin is held in the shuttle, being full of yarn, the bobbin will not fit properly, and causes a break-out in the loom. A careful weaver could prevent this, but even then the bobbin is generally too big to go into the shuttle, and together with others is sent back to the spinning-room, where it is wasted by being cut or reeled off. These bobbins are almost always the result of carelessness of the doffers. They should be trained to glance under the ring rail after every doff, and never to leave a frame until all the bobbins are down. Many of these bobbins fail to fit, because they have been wet or steamed and the wood has swollen. Such bobbins should all be laid aside, and reamed. The Draper Company has recently patented a clutch for the bobbin, which by centrifugal force firmly binds the bobbin when the spindle is running, but when not running the arms of the clutch remain in a normal position, and the bobbin is

free. This device will also prevent spindles being sprung and bolsters broken by the doffers when an extra tight bobbin is found. Its chief merit of course is to prevent the bobbin rising when the frame is running. This is an ever-present trouble on high-speed spindles, and may be caused either by badly fitting bobbins or by vibrating spindles, but in nine cases out of ten it is caused by yarn being wound about the base of the spindle, preventing the bobbin from binding properly. The experience of the writer has been that the bobbins stay down better on the Whitin spindle than on other makes.

With the best system, a good many tangled and the ill-shaped bobbins will be returned from the weave-room. If the mill is of sufficient size, it will pay well to get a quiller and run all these pieces into full-size bobbins. The yarn if cut or reeled off is worth about 6 cents per pound, but if put into shape to weave, from 20 to 30 cents. Not only is it a great saving in this respect, but it has been found by experience that the spinner will be more careful of the shape of his bobbins, and that the quantity of the bad ones will be reduced fully one-half.

Soft Bobbins and Soft Nose Bobbins.—We once knew of a large mill where there was great complaint on account of the filling knocking off in the looms. A rigid investigation showed that they were using a traveller that was too light.

Further investigation showed that the spindles and rings were so badly set that they had to use light travellers, or the ends would not stay up. After the spindles and rings were re-set, they were enable to use a traveller two numbers heavier, and the complaint stopped. Soft bobbins on warp frames are frequently caused by their not being doffed as soon as full.

Sometimes only the nose of the bobbin is soft, and will snarl in the shuttle. This is usually caused either by the builder-cam being worn and allowing a pause in changing, or by too much back-lash in the builder motion. The effect of this back-lash is heightened if the ring rails are too evenly balanced. The rails should be heavy enough to go down quickly, or light enough to go up quickly. The speed of the ring rail may be too slow. It should move fast enough to prevent the coils of yarn riding on each other. After the wind reaches the highest point, it should descend rapidly so as to firmly bind the previous layer. Some spinners change the traverse so as to go up fast and down slow, claiming that the quick downward stroke tends to jerk the ends down. This tendency does not amount to anything, and may be disregarded. Soft twisted filling is less liable to tangle than hard twisted, as it will mash into the yarn previously spun and bind more firmly.

A light traveller will also cause bad noses, es-

pecially in connection with high speed. The yarn is not wound tight enough, and the centrifugal force throws the layers out and loosens them.

GENERAL INFORMATION.

The length of spinning frame is found by multiplying one-half the number of the spindles by the space, and adding 2′ 3″. The width may be 36″ or 39″ as is desired. If the space is ample, a 39″ frame is preferable, as the bands are longer, and have a better bearing surface on the whirl. English frames are much longer than they are usually made in America, often having over 400 spindles. They usually have two cylinders 10″ in diameter, and are frequently belted in the center. Instead of clearer boards, they have clearer rollers on the top rollers, similar to a mule. These rollers lie between the front and middle roller, and are turned by friction.

Separators are called anti-ballooners in England, and have not attained the degree of excellence they have in this country. Ballooning is not an unmixed evil, but helps turn the traveller. If the yarn is allowed to balloon, a heavier traveller can be used, which for several reasons is desirable. Among some mill men there is a tendency to dispense with separators, especially with fine yarn, by making the space between the spindles greater. For filling fames it is customary to have this extra space and to dispense with sep-

arators. This is not the result of any special design, but is merely incidental. The cost of a spinning frame is based on a $2\frac{3}{4}''$ space, and for all numbers, except very coarse ones, the ring is $1\frac{1}{4}''$, allowing ample room on each side.

About $1\frac{1}{4}$ spindles occupy a square foot of floor space, so that 5,000 spindles would occupy 4,000 square feet. Spinning frames are sold at what is known as a base price per spindle. At present this price is \$3.25. Separators are 10 cents extra. Shell front rollers 5 cents, and Dickson's saddles 2 cents. Extra heavy spindles or wide space is also extra. There is also an extra charge for boxing of 2 per cent of the total cost, including extras.

Spinning frames are driven with any size pulley or belt desired. We do not think that less than a 12-inch pulley or a 3-inch belt should be used for a frame of over 200 spindles. It is true, they often have smaller dimensions, but the belt has to be kept so tight that it quickly wears out, and also wears the bearing.

The power required to drive spinning frames depends greatly upon the speed, and increases at a greater ratio. The Draper Company has made exhaustive experiments, and has found that a horsepower will run 137, 94, 76, and 67 spindles at 7,000, 8,000, 9,000 and 10,000 revolutions respectively. Of this power the bare spindle ab-

sorbs more than half, the various elements being as follows:

Cylinder, bands and bare spindles	54 per cent.
Average yarn load	16 per cent.
Average traveller pull	22 per cent.
Rollers, traverse and gears	8 per cent.
	100

For ordinary cotton the front rollers are 1″ in diameter, and the middle and back $\frac{7}{8}$″. The front roller is made larger partly to support the heavier weight and partly so that it does not have to turn so fast to make the surface speed. For India cotton the front roller is $\frac{7}{8}$″, as the cotton is so short the rollers could not get close enough together if they were of the usual size. For some purposes the front rollers are made 1 1-16″ and 1 1-8″ in diameter.

In England, filling frames or mules are always made to give yarn the reverse twist. There is some science in this, as the fibers have been twisted the opposite way in previous processes, the tendency is for them to remain that way. When the twist is reversed, the fibers will not lay so close together, and the yarn is what is called oozy, and gives a softer feel to the cloth. It is also claimed that the fibers being laid in a different way gives the yarn a different color, owing to the direction in which the light strikes it. It is a well-known fact in weaving that stripe effects are made in cloth by having right- and left-hand twist alternate.

CHAPTER VI.

MULE SPINNING.

About one hundred and thirty-five years ago, or to be more exact, between 1764 and 1768, James Hargraves invented a spinning machine called the spinning jenny. It consisted of a row of vertical spindles, driven by bands from a cylinder, which was driven by a large band from a hand wheel. The roving was drawn away from the spindles by a slide, and when drawn out twist was put in by turning the spindles. The slide was then reversed and the twisted yarn was wound on the spindles.

About the same time, Arkwright invented a spinning machine, which on account of its being driven by water power, was called a water frame. It had a set of rollers for drawing out the roving, and the yarn was wound on a bobbin by means of a flyer. About ten years after this, Samuel Crompton invented a machine which retained the drawing-out and winding features of the jenny, but had the rollers of the water frame. From the fact that it retained features of both machines, and was in this respect a hybrid, it was called a mule, a name which it has retained ever since. The first mules were called hand mules, not because they were run by hand, but because many of the motions now done automatically

were then done by hand. On this account, a very skillful man was required to attend to the various details, and only one machine could be run by an operative. Many successive improvements were made, until now all the motions are automatic, and the machine is known as a self-acting mule.

The action of the mule is very complex, or rather the mechanism. Three lines of rollers draw out the roving just as in a spinning frame. Here the similarity ceases. When the rollers begin to deliver the roving the other end is held by the spindle, which is only a few inches from the rollers. As the roving is delivered, the carriage holding the spindles gradually recedes for about five feet, the spindles in the meantime rapidly revolving, thereby putting in the twist. The rollers do not deliver the yarn quite as fast as the carriage recedes, and an additional draft takes place, which is known as the gain, and is usually about three inches. This action, as was explained in the previous chapter, has a very important bearing on the quality of the yarn. When the carriage stops, the rollers stop delivering the yarn, but usually the spindles run a little longer and complete the twisting process. This twisting process contracts the yarn, and if it is very fine will break it, unless there is a mechanism to compensate for the contraction. There is now from 60 to 66 inches of twisted yarn between

the spindles and the rollers, and also a few inches wound in a spiral on the spindles between the top or nose of the cop and the top of the spindle. In order to uncoil this, the spindles run backward a few revolutions, after which the carriage starts back towards the rollers much more rapidly than it came out. While this is taking place, the spindles are slowly turning and winding the slack yarn, which is guided by two tight wires stretched the entire length of the carriage, and known as the fallers and counter-fallers. The whole process from the time the carriage leaves the rollers until it returns, is called a "draw" in England, and a "stretch" in this country.

A very little reflection will show how complicated the machine is. The rollers must stop at exactly the right time. The carriage motion must be square with the head-stock. The backing off must be exactly right, and the filler motion must be suited to the shape of the cop, or the yarn may be stretched on one hand or kinked on the other. The problem is somewhat similar to that of winding roving on a bobbin constantly increasing in diameter, for of course the base of cop is larger than the apex. Then, too, the base is wound on a cop tube, which is usually a true cylinder, and after the base is wound provision must be made for the taper of the spindle. The spindles, too, have varying speed. As they begin to revolve, the speed is gradually accelerated, and

is diminished as the carriage nears the beam. Taken as a whole, the mule is probably the most complicated machine in existence, besides which a Linotype or Northrop loom is a mere toy. Were it not for the fact that such a vast industry depends upon it, it would never have received the attention necessary for its present development. The very fact that so many are concerned in its success, has given it the benefit of many inventors. Were its manufacture a monopoly, it is safe to say it would not have attained its present degree of excellence, but there always being at least half a dozen large machine builders at work on them, a great many inventions are tried where one meritorious one is adopted.

CALCULATIONS.

The calculations in mule spinning are more complicated than in ring spinning, and there are a number of methods of arriving at the same result. We give below what we consider the simplest methods for the most necessary calculations.

Draft.—Where very short cotton is being spun, there is no gain in the carriage, and the calculation is exactly as for ring frames.

Driving.	Driven.
Diam. of front roller 8 (eighths)	Diam. of back roller 7 (eighth)
Back roller gear 60.	Draft gear 45.
Crown gear 120.	The front roller gear 20.

$$\frac{8 \times 60 \times 120}{7 \times 45 \times 20} = 9.14 = \text{Draft.}$$

Draft constant = draft multiplied by draft gear.

To find the draft when there is a gain in the carriage: If the roller delivery is 60″, and the total stretch is 64″, making a gain of 4″, the draft is evidently 1 4-60, or 1.066. We found when considering the draft in the drawing frame that the total draft is the product of the separate drafts, so in the above example the total draft is 9.14 × 1.066 = 9.74.

To find the draft in the rollers when the numbers to be spun, the gain, and the hank roving are known:

Rule.—*Subtract the gain from the total stretch. This gives the amount to be delivered by the rollers. Multiply this by the numbers required, and divide by the product of the stretch multiplied by the hank roving.*

Example.—Number to be spun 40's, hank roving 5, stretch 64″, gain 4″, what draft is required in the rollers?

$$64 - 4 = 60$$

$$\frac{60 \times 40}{64 \times 5} = 7.05 = \text{Draft.}$$

TABLE OF DRAFT CONSTANTS. MASON MULE.

	Inch.		Inch.
Diameter of Front Roller	1	Diameter of Front Roller	1
Diameter of Back Roller	$\frac{7}{8}$	Diameter of Back Roller	$\frac{7}{8}$
Front Roller Gear......	30	Front Roller Gear	30
Change Gear................		Change Gear................	
Crown Gear............	110	Crown Gear............	130
Back Roller Gear.......	70	Back Roller Gear.......	70
Constant....293.40		Constant....346.58	

Constant $\div$ Draft = Draft Gear.

TABLE OF LENGTH AND WEIGHT OF COPS.

Gauge of Mule.	Length of Cop.	Weight of Cop.	Gauge of Mule.	Length of Cop.	Weight Cop.
2	8	1200 grs.	$1\frac{5}{16}$	6	350
$1\frac{3}{4}$	8	1000	$1\frac{1}{4}$	$5\frac{3}{4}$	300
$1\frac{1}{2}$	$7\frac{1}{2}$	600	$1\frac{3}{16}$	$5\frac{3}{4}$	250
$1\frac{3}{8}$	$7\frac{1}{4}$	500	$1\frac{1}{8}$	$5\frac{3}{4}$	200

To find the number of stretches in a cop:

Rule.—*Multiply the weight in grains by the number of yarn and 840, and divide by 7,000. This will give the number of yards in a cop. Multiply this by 36 for the number of inches and divide by the number of inches in a stretch.*

Example.—How many stretches in a cop of 30's made on $1\frac{1}{2}''$ space, stretch $64''$?

Referring to table, we find that the cop will weigh 600 grains.

$$\frac{600 \times 30 \times 840}{7000} = 2160 \text{ yards.}$$

$$2160 \times 36 = 77760 \text{ inches.}$$

$$\frac{77760}{64} = 1215 \text{ stretches.}$$

To find the change gear on builder screw:

Rule.—*Divide the number of stretches in a cop by the number of thread in use on the screw.*

TABLE OF CONSTANTS FOR BUILDER GEARS. MASON MULE.

Space of Mule.	Threads in Use.	Weight of Cop.	For 60 Inch Stretch.	For 64 Inch Stretch.
2	52	1200	1.69	1.56
$1\frac{3}{4}$	52	1000	1.38	1.29
$1\frac{1}{2}$	52	600	.83	.78
$1\frac{3}{8}$	52	500	.55	.52
$1\frac{5}{16}$	52	350	.48	.44
$1\frac{1}{4}$	52	300	.42	.39
$1\frac{3}{16}$	52	250	.34	.32
$1\frac{1}{8}$	52	200	.27	.26

Constant × No. of yarn = Gear.

TWIST.

The twist in mule-spun yarn varies greatly according to the purpose for which it is intended and also according to the quantity of cotton. As we stated in a previous chapter, the usual custom is as follows:

Hosiery yarn, the square root of number × 2.50.
Yarn for doubling, the square root of number × 2.75.
Filling yarn, the square root of number × 3.25.
Warp yarn, the square root of number × 3.75.

When the mule is running, the easiest way to get the twist is to get the speed of spindles by means of a speed indicator on cylinder shaft. This number divided by the inches in a stretch gives the twist being put in. When it is desired to calculate the twist, it becomes a very difficult

matter to make a universal rule. In fact, such a rule is impossible, for various makes of mules have different arrangements for driving the spindles and rollers. The following is the method of getting the twist for a Mason mule where the rim pulley is at the back, and will apply to any mule with similar arrangement of gears:

Example.—Diameter of rim pulley, 15 inches; diameter of cylinder, 6 inches; spur portion of spur and bevel compound gear, 50 teeth; bevel gear on front roll sleeve, 48 teeth; diameter of spindle whirl $\frac{3}{4}''$; diameter of pulley on cylinder shaft, 10 inches; speed change gear, 30 teeth; bevel portion of spur and bevel compound gear, 24 teeth; cir. of front roller, 3.1416 in.

Then—

$$\frac{15 \times 6 \times 50 \times 48}{.75 \times 10 \times 30 \times 24 \times 3.1416} = 12.73$$

This is the theoretical twist, from which deductions must be made for size of bands and also slip of bands.

To change the twist gear when changing numbers, the rule is the same as for other machines, viz., *square present gear, multiply by numbers required, divide by the number being spun, and extract the square root of the quotient.*

PRODUCTION.

The production of mules is not altogether like other machines depending on the twist. When a change in the numbers is desired, there are two places where the twist is changed. It may either be done by changing the rim wheel, which will change the speed of spindles, or the speed gear may be changed, changing the speed of the rollers. The latter method is usually adopted, except when very wide variations are desired. The following table gives an average speed, which under favorable conditions is sometimes exceeded. It is calculated for a ten-hours run, and an allowance has been made for necessary stops.

PRODUCTION TABLE FOR MULES, 10 HOURS.

Number of Yarn.	Stretches Per Minute. 64 Inches.	Hanks Per Spindle Per Day.	Pounds Per Day. Without Roller Motion.	Pounds Per Day. With 5 Per Cent Roller Motion.
6	6.00	6.85	1.14	1.20
8	6.00	6.85	.85	.89
10	6.00	6.85	.82	.85
12	6.00	6.85	.57	.59
14	5 50	6.28	.45	.47
16	5 50	6.28	.39	.41
18	5.50	6.28	.35	.36
20	5.50	6.28	.31	.33
22	5.50	6.28	.28	.29
24	5.50	6.28	.26	.27
26	5.25	6.00	.23	.24
28	5.25	6.00	.21	.22
30	5.25	6.00	.20	.21
32	5.25	6.00	.18	.19
34	5.25	6.00	.17	.18
36	5.125	5.85	.161	.170
38	5.125	5.85	.153	.161
40	5.00	5.71	.141	.148
42	5.00	5.71	.135	.141
44	4.75	5.42	.121	.128
46	4.75	5.42	.116	.123
48	4 50	5.24	.108	.113
50	4.50	5.24	.103	.110
52	4.25	4.85	.091	.097
54	4.25	4.85	.089	.093
56	4.25	4.85	.085	.090
58	4.25	4.85	.083	.085
60	4.125	4.71	.078	.083
62	4.125	4.71	.075	.078
64	4.125	4.71	.073	.076
66	4.125	4 71	.070	.073
68	4.00	4.57	.066	.070
70	4.00	4.57	.065	.068
72	4.00	4.57	.063	.066
74	4.00	4.57	.061	.063
76	4.00	4.57	.060	.061
78	4.00	4.57	.058	.060
80	4.00	4.57	.057	.059

Mule Cop Building.—Cop building in the true sense of the word, must not be confused with building cops on an old mule that has been fixed time and again. In order to understand the subject, it is necessary to understand the principle on which the machine operates. There is a difference in this respect between different makes of mules. When a man attempts to file a coping rail or plate, he must first know what principle is used on the mule he is to work on. On an automatic engine lathe, the reverse of the pattern being set just where the tool post will pass it, it what is called the direct principle. In this case there is a hollow place on the pattern presented to the adjusting part of the tool post, and it will form a bulge on the piece being turned, or a bulge on the pattern will form a depression. However, if the action of the cutter in the tool post is worked on the double action principle, a correct counterpart of the piece to be turned must be in front of the tool post. The action of the rail in the mule is similar. If the motion to the fallers is direct, when there is a hollow in the rail it will produce a bulge in the cop, but if the action is transmitted to the fallers through double-acting mechanism, it will have the opposite effect on the cop. We must bear in mind that the length of the nose will be the perpendicular height between the highest and lowest part of the rail. It is possible to upset all calculations by

having part of the rails flattened, rounded or hollowed, so that the fallers are almost brought to a standstill, and no mathematical equation can determine exactly where the yarn will be wound. We know that if the faller is retarded while it is passing the highest part of the rail, it will wind too much at that point. We also know that the superfluous coils will fall over each other and we get "run under" cops. From the highest point in the front coping plate, generally marked as the standard, and the highest part in the back plate, also so marked, the lengthening out of the nose will be regulated until the cop bottom is fully built, and the plates will at the same time be on the point of the true inclined plane on both plates alike, and thus maintain a straight-bodied cop during the rest of the set.

Although the quadrant has an important part to play in the building of a cop, that part will be fully discussed a little further on. The writer has heard and read a great deal of advice as to how to build a well-shaped cop by moving the plate in or out a little. Of course this will shorten or lengthen the nose, but it is not the proper place for that adjustment. This should be adjusted by the screws in the rail intended for that very purpose. Moving the back plate in or out has been the beginning of a great deal of trouble with mule cops. One plate is brought to the straight incline before the other, and the

inexperienced man will attempt to correct the trouble by filing the plate. If this has been done, the plates should be put back, and when they have been turned well down on the straight incline, the length of the nose can be adjusted by the adjusting screws in the rail. The faller should now be set at the right height on the spindle by the slot and screws in the faller leg. Care must be taken that the center of action in the faller will be between the spindle bolsters and where the faller stops up. If this is out of position one way, it will build thick at the bottom and thin at the top; if the other way, thin at the bottom and thick at the top.

Bad Cop Noses.—The causes for these are legion. A great many bad cops are made through ignorance, and also a great many by neglect, or in order to make the work easier for the spinner. Sometimes when the yarns are spun from short or weak cotton, they will not stand much strain, and the operative will run the quadrant chain too high, paying off too much slack yarn. This will make soft cops, for if there is too much weight on the under faller to get the cops fairly firm, it will be so high just before the mule reaches the back stops, that it would require the nose peg to be well down in the slot in the quadrant arms in order to take up the slack yarn and make a firm, evenly-tapered nose. This being the case the spinner allows it to go slack, and hence we have soft

noses. All kinds of tender yarns need very careful handling in spinning as well as in other processes. There are many kinds of goods which require this tender yarn, and we must have it made with good noses. In order to do this, we must have as few faller weights as can be run with. The quadrant chain must not be too high. The quadrant must be set so that it will give a medium wind. If the quadrant has too many teeth out from the pinion forward, the under faller rising too high, the winding will commence too slack, but will finish too tight, and there will be too much pressure on the weak yarn. Some of the ends may be broken, but a great many more will be strained. On the other hand, do not have the quadrant too far front, or it will start winding too tight and end too slack. The mean between the two extremes must be found, so that the under faller will ride about an inch above the spindles' points until just before the carriage gets in. It will not require much nose peg to take up the slack yarn caused by the short distance the faller has to rise after unlocking. There must be good judgment used in adjusting the faller chain. If the mule has an automatic tightener, it should be adjusted so as to follow the yarn closely during backing off. It must not press too much, or it will build a long, thin nose, laying too many coils on the point of cop at each stretch. If the adjusting of the faller chain has to be done by

hand, the spinner must be taught to notice it every time he passes it, and turn the screw for that purpose a little each time, but to do it frequently. He must also be taught to keep the rim band at a nice tention, and not too slack, or the carriage will bounce out as though the belt were too tight. If it is too tight it will act as a break on the cylinder shaft during winding. Either of these extremes will have a bad effect on the yarn.

The proper adjustment of the drawing-in scrolls will have considerable effect on the noses. If the scroll is too far back, with the thicker part of the scroll taking hold of the drawing up, the carriage will start off too abruptly, putting a sudden strain on the yarn and probably breaking many ends. It will also get to the smaller part of the scroll just as the carriage should keep up a steady pace. This will retard the carriage in such a way that any one standing at the mule end can notice it hanging a little. This will not only tend to cut the yarn, but prevent the fallers from making a clean nose. Like setting the quadrant, the mean between this and starting the carriage off too slow must be carefully found. The carriage must start off easily but firmly, keeping up a steady speed and getting the necessary retardation at the proper time. We must especially avoid sudden changes of tension, and the carriage should get to the back

stops just as the fallers unlock, without jerks. The inclined slide on the floor under the "salmon head" that holds the faller weights must be properly adjusted. There should be from one- half to three-quarter inches from the face of the salmon heads, so that the under faller may just hold the yarn when the mule is backing off. The others should just touch, and the inclines should be of that pitch so that the salmon heads will slide evenly down until they all bear equally on the yarn without any jerk or sudden change of tention. This adjustment is for weak yarns. Stronger yarns will require a slightly different arrangement.

The good spinner will have but little trouble along these lines, and the above is written for those who do. There are some makes of mules where the quadrant can not be adjusted to get a steady wind for all kinds of work. One tooth is too much either way. There are other mules where the position of the quadrant can be change by the bands almost to a hair's breadth. The rail is so constructed on some mules that it is very difficult to finish off a nose on tender yarn. The writer, when spinning hosiery yarn and coarse filling for cotton flannel, has taken out the rails and planed them off gradually for five or six inches from nothing down to one-quarter inch, and found that it helped matters a great deal. The fallers went up quicker at the point

and left a loose coil just above the nose, giving a good finish. Many new mules are now built this way.

Cut Yarn.—In discussing this we will assume that the roving is all right, but will warn the spinner that he is expected to watch the roving carefully and call the carder's attention to any defect. There are a great many causes for cut yarn. One of the principal ones is improper setting of the gears. A great many men have the idea that gears should be set as deep as possible. They were never made with this intention, and if set just deep enough, will give a much smoother motion than if they bottom. Gears which are badly worn should never be used on the rollers. They are put into gear so deep that the rollers have a trembling, jerking motion which is very injurious to the yarn.

The majority of the causes which tend to make cut yarn on the mule will also cause it on the ring frame, and have been fully discussed under that head. There are a few causes which are peculiar to the mule, and among them is that of having the belt too tight. When this is the case the carriage bounces out from the beam with a sudden jerk. This is especially the case just after doffing, when the spindles turn easier on account of the lighter loads. It will also occur when the carriage is not square. In these days, when there is a great push for production, there is a

great tendency to run belts too tight. This is bad on the yarn, especially when there is a small rim band. When the mule is very long, with a perpendicular driving belt, and perhaps short at that, a small top pulley and but little contact on the driving pulley, the belts must be tight in order to do the work. In this case, it is a good idea to put a pinch of powdered starch on the belt every three or four minutes for about a half an hour. By this time the spindles begin to get weighted, and the belt will be all right.

Squaring the Carriage.—This part of mule work seems so simple that almost any boy in the room thinks he can do it, but there are times when it is not such an easy job. It is all very easy when we know that the top band has stretched and allowed the carriage to go too far in. It is necessary then to tighten the top band, but care must be had that the carriage is not too near the beam, leaving only a few inches of the under rope off the scroll. When we turn the back shaft and lift up the mendozen when the carriage gets out, we will find it will spring back some, and the carriage will still be out of square. Again, the other top band may be already too much forward, allowing very little of the incline on the drawing-out scroll to come into play. In this case, the carriage will strike out too hard, or the reverse may be the case. A good plan, when we know the bands are all right and the carriage is square,

is to put a chisel mark through the end of the back shaft at the mule end. Afterward, when we come along and see that the mule is not square we can tell at a glance if the back shaft needs regulating by the middle band before working at the end. A good man can often do better work while the mule is working than by stopping it and using his rule. Mule men should train their eyes well, and can tell by looking at a carriage if the bands are properly adjusted. Sometimes the carriage may appear to be out of square when it is really not the case. Examine the back couplings, the drawing out scroll fastenings, keys and set screws, lift up the mendozen, slack off all the drawbands, twist the shaft well at every joint or scroll, and you will often find the evil which has bothered many men for weeks.

GENERAL INFORMATION.

Mules are usually set across a mill and occupy the whole space, except perhaps three feet on each side for a passway. The number of spindles will depend on the available space. A rule to obtain the length is to multiply the space by the number of spindles and add 6 feet. Thus, a mill 100 feet wide would take mules of 530 spindles if 2-inch gauge, and 550 if $1\frac{1}{2}$ inch. These mules would be rather short, and it would be better to have a mill 125 or 150 feet wide. A pair of mules, having a 64-inch stretch, occupy a space of about 18

feet from back to back of creels, and 20 feet from back to back of head-stocks. As these dodge one another, a 22-foot space will allow sufficient room for creeling, etc. It will be seen then, that mules occupy about two square feet of space per spindle, or something over twice as much as spinning frames. Mills built for mules usually have the bays wider than if built for a spinning frame. If the bays have the usual 8-foot span, there will either be a good deal of waste of space, or the mules will have to be lengthways with the mill, which is not so good an arrangement on account of the creels shutting off the light.

Until twenty or twenty-five years ago, numbers finer than 100 were spun on hand mules, as it was found very difficult to build a mule that would spin the fine numbers automatically without stretching the yarn. Now, however, the self-acting mule can spin 300's as well or better than it could spin 100 a few years ago. For experimental purposes, as high as 2000's have been spun, but for practical purposes 400's is about the limit.

For spinning fine numbers special attachments are put on the ordinary mule. The principal motions for this purpose are as follows:

Jacking out, or causing the carriage to run out very slowly during the last few inches.

Roller motions, or the delivery of a few inches of yarn while winding and twisting.

Double speed, or two sets of pulleys on counter shaft and rim shaft. These are to give the spindles a slow speed when the carriage is running out, and a much quicker one when it reaches the end of the stretch.

Roller bearings for fallers and counter-fallers.

Single boss rolls, or only one thread for each boss.

Second, or after-stretch motions.

Electricity is now being used by some of the European builders for driving the mule, a motor being placed on the carriage and one on the head-stock. Motors have been used to some extent in driving spinning frames also. We do not mean for driving the shafting, for that is being done in in a dozen mills in North and South Carolina, but driving the frames direct, a motor being placed between two frames and connected to each by friction clutches. The first mill in which this was tried on any considerable scale gave the plan a bad name from which it has never recovered. It was known that about $2\frac{1}{2}$ horse power was required to run a frame, so a motor of 5 horse power was put in for two frames. The engineer failed to consider the fact that while $2\frac{1}{2}$ horse power would run a frame, it took at least double that to start it, and the plan was a complete failure until much larger motors were installed.

A mule of $1\frac{3}{4}$-inch space, having 468 spindles,

costs $2.68 per spindle. The weight per spindle is about 20 pounds, practically the same as for spinning frames, or perhaps a little less. A horsepower will run from 125 to 150 spindles. It will be seen that they are much more economical with power than a spinning frame. The casual observer would suppose the opposite to be the case. The difference lies in the fact that on the mule the spindle motion, which absorbs more than half the power, is intermittent. Then, too, the mule has no traveller pull, which is nearly one-fourth of the load of a spinning frame.

CHAPTER VII.

PROCESSES SUBSEQUENT TO SPINNING.

SPOOLING.

Unless it is to be dyed, yarn spun for filling goes direct from the mule or spinning frame to the loom, and we will not treat of it further. Yarn for other purposes is either coned or spooled, and as most of it is spooled, we will consider this first. A spooler is so simple a machine that its importance is often lost sight of. The cost of spooling per pound often exceeds the entire cost of carding. A great deal of bad work is often done at the spooler, and considering the amount of skill required by the operator, the spooling process will stand as much intelligent supervision as any department in the mill. A few years ago long knots were the chief trouble about spooling, but now practically all the mills use the Barber knotter, and this trouble is eliminated. Within the past few months a knotter has been imported from England which sells for $1.25, and seems to do the work effectively. In England, the spoolers are required to tie weavers' knots.

CALCULATIONS.

The only calculation about a spooler is for production. This varies a great deal with the skill

of the operative, and on other conditions. The writer is satisfied that a great deal of bad yarn is caused by its being strained at the spooler. Warp yarn should possess as much elasticity as possible in order to enable it to stand the sudden and severe strain of shedding and beating up in the loom. If the yarn is spooled at high tension, which is almost synonymous with high speed, much of this elasticity is taken out and the weaving suffers. If we take a spool 4 inches in diameter with $1\frac{1}{2}$-inch barrel, a little calculation will show that when the spool is full, not counting the piling-up process, it is winding between 2 and 3 times as fast as when empty. If the spindles run 800 revolutions per minute, the yarn is winding at the rate of 280 yards, or 25 times as fast as it is being spun. For the best results, the spindles should never run faster than 800 revolutions, and even a slower speed in many cases would be beneficial. With a slower speed, the spooling does not cost any more, but simply calls for more spindles.

PRODUCTION TABLE FOR SPOOLERS, 10 HOURS.

Spools. Length.	Spools. Diameter.	Weight of Yarn on Spool.	Number of Yarn.	Revolutions of Spindles. 750 Pounds.	Revolutions of Spindles. 800 Pounds.	Revolutions of Spindles. 900 Pounds.	No. of Spinn'g Spindles to one Spooler Spin.
6 in.	5 in.	30 oz.	8	10.7	11.5	12.9	12
			10	8.6	9.2	10.3	
			12	7.2	7.7	8.6	
			14	6.2	6.6	7.4	13
			16	5.4	5.8	6.5	
6 in.	4 in.	19 oz.	18	4.8	5.2	5.8	
			20	4.3	4.6	5.2	14
			22	3.9	4.2	4.7	
			24	3.6	3.8	4.3	
			26	3.3	3.6	4.0	15
			28	3.1	3.3	3.7	
			30	2.9	3.1	3.5	
5 in.	4 in.	16 oz.	32	2.7	2.9	3.3	16
			34	2.6	2.8	3.1	
			36	2.4	2.6	2.9	
4½ in.	3½ in.	11 oz.	38	2.3	2.4	2.7	17
			40	2.2	2.3	2.6	
			44	2.0	2.1	2.4	18
			50	1.8	1.9	2.1	19
4½ in.	3¼ in.	9 oz.	60	1.5	1.6	1.8	20
			70	1.3	1.4	1.5	21
			80	1.1	1.2	1.3	22
3 in.	2¾ in.	4 oz.	90	1.0	1.1	1.2	23
			100	.9	1.0	1.1	24

If the length of yarn on a spool is desired, multiply the weight in ounces by $437\frac{1}{2}$ to reduce it to grains, and divide by 840, multiplied by the number of yarn. Fine numbers will weigh and measure more in proportion than coarse numbers on account of the strands lying closer together. A good deal of energy is sometimes lost trying to change the traverse so that the yarn will lay closer together, enabling more yarn to be put on a spool. All that can be done is to get a mean between the full and empty spools, and arrange the traverse so that when the spool is half full the coils are as close together as possible without riding. To be mathematically correct, half full means when half the number of bobbins have been wound, and not when half the available diameter is full.

It is sometimes necessary to change a spooler from a 6-inch traverse to a shorter one. On the Whitin spooler, or any other where the traverse is worked by a gear, the change is effected by changing the number of teeth in proportion to the change desired in the traverse. If the present gear has 18 teeth, and is running a 6-inch traverse, it takes three teeth for each inch, and 15 teeth will make a 5-inch traverse. On some spoolers the change will have to be made by shortening the rocker arms.

One of the principal troubles about a spooler is running the spools so full that the yarn is

liable to tangle off. A good way to prevent this is to have a board put just back of the spool the whole length of the frame, just thick enough for a full spool to go on. With this arrangement, when the spool gets full enough, the friction on the board will stop it, and it can be replaced by an empty one.

Waste.—A great deal of waste is frequently made by one head of the spool coming off, which is usually caused by letting the spool fall. A preventive is always better than a cure, and the best preventive is to use spools bound with raw hide. They cost about $3\frac{1}{2}$ cents more than the ordinary kind, but are certainly worth the difference. In a mill where number 20's was made and the spools used very often, a lot of 1,200 of these spools were used for nearly three years, only one breaking, while the ordinary kind were being broken every day. However, all mills do not have these, and where a spool holds a pound of yarn it is too great a waste to throw it away. If the yarn remains solid and has not begun to tangle off, the end of the spool can be coated with tallow, which when it hardens will make it firm enough to be run off. This would not work very well if the yarn were to be dyed. But for white work it is all right. If only part of the head is broken, a nail can be driven into the barrel so as to keep the yarn from tangling.

Big-Ended Spools.—These are usually caused by having the traverse nearer one end than the other. In order to have a barrel-shape to the spool and get more yarn on it, it is customary to have the traverse from 1-16th to 1-8th inch short at each end. Where this distance is not equal at both ends, an ill-shaped spool is made. This is not always the cause. On some spoolers the lifting rods are lifted by chains running over rollers. If the rollers are placed so that the chain is not exactly parallel to the lifting rod, a cone-shaped spool will be formed.

GENERAL INFORMATION.

Spoolers are usually built with 100 spindles, but can be had with any number from 40 to 200. The length can be ascertained by multiplying one-half the number of the spindles by the space, which should be three-quarters of an inch more than the diameter of the spools, and adding one foot. The width is about 4 feet 9 inches, including bobbin boxes. Spoolers cost about $3.00 per spindle, and weigh from 30 to 40 pounds per spindle. About all machine builders now make them with metal creels and boxes, which are much better than wooden ones. About 300 spindles will absorb a horsepower. An operative usually attends to one side of the spooler, which is generally 50 spindles. On very coarse yarn two will be needed for one side, giving 25 spindles to each. It is always well to determine before-

hand about how many spindles an operative can keep up for the number of yarn it is proposed to make, and order the length accordingly. Thus, if number sixteens were to be spun, 50 spindles would be too much for one hand and not enough for two.

TWISTING.

Twisting in England is usually done on a mule which is called a twiner. They are generally made with a movable carriage, but sometimes with the carriage stationery and the creel movable. The English were slow to appreciate the advantages of the ring spinning frame, and slower still those of the ring twister. They call the latter a ring doubling frame.

On worsted and silks, where the cost of the material is great, the doubling is often done on a separate machine—a doubling spooler—so that the waste is not nearly so great. Cotton mills usually spool the yarn separately, and do the doubling on the twister. On two-ply work, the number of twister spindles is about one-half that required for spinning. The essential features are the same as in a spinning frame, the only difference being the rollers and creels.

Calculations.—There are only two calculations about a twister, viz., production and twist. These are intimately associated with each other, the less the twist the greater being the production.

Twist.—The rule for twist of ply yarn generally used in England is the same as for warp on the spinning frame, viz., 3.75 times the square root of the number. By the number we mean the number after it is twisted, 50's twisted 2-ply will make 25. The square root of 25 is 5, and 5 times 3.75 is 18.75. Yarn twisted by this standard will not kink but look round and even. In America, more twist is usually put in, there being three so-called standards. These are 4, 5 and 6 times the square root of the number of the yarn after it is twisted. For convenience of reference, we give on the following pages the production, twist and speed for all ordinary conditions.

PRODUCTION AND TWIST TABLES FOR TWISTED YARN.

TWO PLY.

No. of Yarn to be Twisted.	Rev. of Spindles.	Square Root of Twisted Yarn.	Sq. Root X 4.			Sq. Root X 5.			Sq. Root X 6.		
			Twist.	Rev. of Roller.	Pro. per Spindle.	Twist.	Rev. of Roller.	Pro. per Spindle.	Twist.	Rev. of Roller.	Pro. per Spindle.
6	4500	1.73	6.93	138	3.98	8.66	110	3.18	10.39	92	2.67
7	4750	1.87	7.48	135	3.34	9.35	108	2.69	11.22	90	2.22
8	5000	2.	8.	133	2.87	10.	106	2.29	12.00	88	1.91
9	5200	2.12	8.49	130	2.50	10.61	104	2.01	12.73	87	1.67
10	5300	2.23	8.94	126	2.18	11.18	101	1.75	13.42	84	1.46
11	5500	2.34	9.38	124	1.96	11.73	99	1.57	14.07	83	1.30
12	5550	2.44	9.80	119	1.71	12.25	95	1.38	14.70	79	1.15
13	5650	2.54	10.20	117	1.57	12.75	94	1.25	15.30	78	1.05
14	5750	2.64	10.58	115	1.43	13.23	92	1.14	15.87	77	.96
15	5900	2.73	10.95	114	1.31	13.69	91	1.06	16.43	76	.88
16	6000	2.82	11.31	113	1.22	14.14	90	.98	16.97	75	.81
17	6000	2.91	11.66	109	1.12	14.58	87	.89	17.49	73	.74
18	6050	3.00	12.06	107	1.03	15.00	86	.82	18.00	71	.69
19	6100	3.08	12.33	105	.96	15.41	84	.77	18.49	70	.64
20	6150	3.16	12.65	103	.91	15.81	82	.73	18.97	69	.60
22	6300	3.31	13.27	101	.80	16.58	81	.64	19.90	67	.54
24	6500	3.46	13.86	99	.73	17.32	80	.58	20.78	66	.49
26	6650	3.60	14.42	98	.66	18.03	78	.53	21.63	65	.44
28	6800	3.74	14.97	96	.60	18.71	77	.48	22.45	64	.40
30	6900	3.87	15.49	94	.55	19.37	75	.44	23.24	63	.37
32	7000	4.06	16.00	93	.51	20.00	74	.41	24.00	62	.34
34	7000	4.12	16.49	90	.46	20.62	72	.37	24.74	60	.31
36	7000	4.24	16.97	87	.42	21.21	70	.34	25.46	58	.29
38	7000	4.35	17.44	85	.39	21.79	68	.32	26.15	57	.26
40	7000	4.47	17.89	83	.37	22.36	66	.30	26.83	55	.24
50	7500	5.00	20.00	79	.28	25.00	64	.22	30.00	53	.19
60	7500	5.47	21.90	73	.22	27.39	58	.17	32.86	48	.15

NOTE—The above table is for 1½ inch roller. 1⅜ inch should make 9 per cent more turns.

PRODUCTION AND TWIST TABLE FOR TWISTED YARN.

THREE PLY.

No. of Yarn to be Twisted.	Rev. of Spindles.	Square Root of Twisted Yarn.	Sq. Root X 4.			Sq. Root X 5.			Sq. Root X 6.		
			Twist.	Rev. of Roller.	Pro. Per Spindle.	Twist.	Rev. of Roller.	Pro. Per Spindle.	Twist.	Rev. of Roller.	Pro. Per Spindle.
6	4000	1.41	5.66	150	6.48	7.07	120	5.18	8.49	100	4.33
7	4300	1.52	6.11	149	5.54	7.64	119	4.43	9.17	99	3.69
8	4550	1.63	6.53	148	4.80	8.16	118	3.83	9.80	98	3.20
9	4800	1.73	6.93	147	4.23	8.66	117	3.38	10.39	98	2.82
10	5000	1.82	7.30	145	3.77	9.13	116	3.02	10.95	97	2.51
11	5200	1.91	7.66	144	3.39	9.57	115	2.71	11.49	96	2.26
12	5350	2.00	8.00	142	3.07	10.00	113	2.46	12.00	95	2.05
13	5506	2.08	8.33	140	2.80	10.41	112	2.24	12.49	93	1.87
14	5600	2.16	8.64	137	2.54	10.80	110	2.03	12.96	92	1.69
15	5750	2.23	8.94	136	2.36	11.18	109	1.89	13.42	91	1.57
16	5850	2.30	9.24	134	2.18	11.55	107	1.74	13.86	90	1.45
17	5850	2.38	9.52	130	1.99	11.90	104	1.59	14.28	87	1.33
18	5950	2.44	9.80	129	1.86	12.25	103	1.49	14.70	86	1.24
19	6000	2.51	10.07	126	1.72	12.58	101	1.38	15.10	83	1.15
20	6000	2.58	10.33	123	1.60	12.91	99	1.28	15.49	82	1.07
22	6000	2.70	10.83	117	1.39	13.54	94	1.12	16.25	78	.93
24	6000	2.82	11.31	113	1.22	14.14	90	.98	16.97	75	.81
26	6100	2.94	11.76	110	1.09	14.72	88	.87	17.66	73	.73
28	6250	3.05	12.22	108	1.01	15.28	87	.81	18.33	72	.67
30	6400	3.16	12.65	107	.94	15.81	86	.75	18.97	71	.63
32	6500	3.26	13 06	106	.86	16.33	84	.69	19.60	70	.57
34	6500	3.36	13.47	102	.79	16.83	82	.63	20.20	68	.53
36	6500	3.46	13.86	99	.73	17.32	80	.58	20.78	66	.49
38	6500	3.55	14.24	97	.67	17.80	77	.54	21.35	65	.45
40	6500	3.65	14.61	94	.62	18.26	75	.50	21.91	63	.41
50	7000	4.08	16.33	91	.47	20.41	73	.38	24.49	61	.31
60	7000	4.47	17.89	83	.37	22.36	66	.40	26.83	55	.25

NOTE.—The above table is for 1½ inch roller. 1⅜ inch should make 9 per cent more turns.

PRODUCTION AND TWIST TABLES FOR TWISTED YARN.

FOUR PLY.

No. of Yarn to be Twisted.	Rev. of Spindles.	Square Root of Twisted Yarn.	Sq. Root X 4.			Sq. Root X 5.			Sq. Root X 6.		
			Twist.	Rev. of Rollers.	Pro. Per Spindle.	Twist.	Rev. of Rollers.	Pro. Per Spindle.	Twist.	Rev. of Rollers.	Pro. Per Spindle.
6	3500	1.22	4.90	151	8.73	6.12	121	6.97	7.35	101	5.82
7	3750	1.32	5.29	149	7.39	6.61	120	5.95	7.94	100	4.95
8	3950	1.41	5.66	148	6.40	7.07	118	5.13	8.49	99	4.27
9	4100	1.50	6 00	145	5.57	7.50	116	4.46	9.00	97	3.72
10	4300	1.58	6.32	144	4.99	7.91	115	3.99	9.49	97	3.33
11	4450	1.65	6.63	142	4.48	8.29	114	3.58	9.95	95	2.98
12	4600	1.73	6.93	141	4.07	8.66	113	3.25	10.39	94	2.71
13	4700	1.80	7.21	138	3.69	9.01	111	2.94	10.82	92	2.46
14	4800	1.87	7.49	136	3.36	9.35	109	2.69	11.22	91	2.24
15	4900	1.93	7.75	134	3.09	9.68	107	2.48	11.62	89	2.06
16	5000	2.00	8.00	133	2.87	10.00	106	2.29	12.00	88	1.91
17	5100	2.06	8.25	131	2.67	10.31	105	2.13	12.37	87	1.78
18	5200	2.12	8.49	130	2.50	10.61	104	2.00	12.73	86	1.67
19	5250	2.17	8.72	128	2.32	10.90	102	1.86	13.08	85	1.55
20	5300	2.23	8.94	126	2.18	11.18	100	1.75	13.42	84	1.45
22	5450	2.34	9.38	123	1.94	11.73	99	1.55	14.07	82	1.29
24	5600	2.44	9.80	121	1.75	12.25	97	1.40	14.70	81	1.17
26	5700	2.54	10.20	119	1.58	12.75	95	1.26	15.30	79	1.05
28	5800	2.64	10.58	116	1.44	13.23	93	1.15	15.87	78	.96
30	5900	2.73	10.95	114	1.31	13.69	91	1.05	16.43	76	.87
32	5950	2.82	11.31	112	1.21	14.14	89	.97	16.97	74	.81
34	6000	2.91	11.66	109	1.12	14.58	87	.90	17.49	73	.75
36	6050	3.00	12.00	107	1.03	15.00	86	.82	18.00	71	.69
38	6100	3.08	12.33	105	.96	15.41	84	.77	18.49	70	.64
40	6100	3.16	12.65	102	.89	15.81	82	.71	18.97	68	.60
50	6450	3.53	14.14	97	.67	17.68	77	.54	21.21	64	.45
60	6750	3.87	15.49	92	.54	19.37	74	.43	23.24	62	.36

NOTE.—The above table is for 1½ inch roller. 1⅜ inch should make 9 per cent more turns.

PRODUCTION AND TWIST TABLES FOR TWISTED YARN.

FIVE PLY.

No. of Yarn to be Twisted.	Rev. of Spindles.	Square Root of Twisted Yarn.	Sq. Root x 4.			Sq. Root x 5.			Sq. Root x 6.		
			Twist.	Rev. of Rollers.	Pro. per. Spindle.	Twist.	Rev. of Rollers.	Pro. per Spindle.	Twist.	Rev. of Rollers.	Pro. per Spindle.
6	2800	1.09	4.38	136	9.77	5.48	108	7.81	6.57	90	6.52
7	3000	1.18	4.73	135	8.31	5.92	107	6.64	7.16	89	5.44
8	3150	1.26	5.06	132	7.13	6.32	106	5.71	7.59	88	4.75
9	3300	1.34	5.37	130	6.26	6.71	104	5.01	8.05	87	4.17
10	3400	1.41	5.66	127	5.51	7.07	102	4.41	8.49	85	3.67
11	3550	1.48	5.93	126	4.99	7.42	101	3.99	8.90	84	3.33
12	3650	1.54	6.20	125	4.50	7.75	100	3.60	9.30	83	3.00
13	3750	1.61	6.45	123	4.10	8.06	98	3.29	9.67	82	2.73
14	3800	1.67	6.69	120	3.72	8.37	96	2.98	10.04	80	2.48
15	3900	1.73	6.93	119	3.44	8.66	95	2.75	10.39	79	2.29
16	3950	1.78	7.16	117	3.16	8.95	94	2.53	10.73	78	2.11
17	4000	1.84	7.38	115	2.93	9.22	92	2.34	11.06	77	1.95
18	4050	1.89	7.59	113	2.72	9.49	90	2.18	11.38	75	1.81
19	4100	1.94	7.80	112	2.54	9.75	89	2.03	11.70	74	1.70
20	4150	2.00	8.00	110	2.38	10.00	88	1.90	12.00	73	1.59
22	4200	2.09	8.39	106	2.09	10.49	85	1.67	12.59	71	1.39
24	4300	2.19	8.76	104	1.88	10.95	83	1.50	13.15	69	1.25
26	4350	2.28	9.12	101	1.68	11.40	81	1.34	13.68	67	1.12
28	4400	2.36	9.47	99	1.52	11.83	79	1.22	14.20	66	1.01
30	4500	2.44	9.80	97	1.41	12.25	78	1.13	14.70	65	.94
32	4550	2.52	10.12	95	1.29	12.65	76	1.03	15.18	64	.86
34	4600	2.60	10.43	94	1.19	13.04	75	.95	15.65	62	.79
36	4600	2.68	10.73	91	1.09	13.42	73	.87	16.10	61	.73
38	4600	2.75	11.03	89	1.01	13.78	71	.81	16.54	59	.67
40	4600	2.82	11.31	86	.93	14.14	69	.74	16.95	57	.62
50	4900	3.16	12.65	82	.72	15.81	66	.58	18.97	55	.48
60	5200	3.46	13.86	80	.58	17.32	64	.46	20.78	53	.39

NOTE—The above table is for 1½ inch rollers. 1⅜ inch should make 9 per cent more turns.

TABLE OF TWIST CONSTANTS. WHITIN TWISTER.

Diam. of Cylinder.	Diam. of Whirl.	Relation.	Cylinder Gear.	Stud Gear.	Constant. $1\frac{3}{8}''$ Roll	Constant $1\frac{1}{2}''$ Roll.
7	$\frac{7}{8}$	7.25	22	88	724.8	688.8
7	$\frac{7}{8}$	7.25	36	74	372.4	354
7	$\frac{7}{8}$	7.25	55	55	181.2	172.2
7	$1\frac{5}{16}$	4 80	22	88	480	456.
7	$1\frac{5}{16}$	4.80	36	74	246.6	234.4
7	$1\frac{5}{16}$	4.80	55	55	120	114
8	$\frac{7}{8}$	8 28	22	88	827.6	786.8
8	$\frac{7}{8}$	8.28	36	74	425.4	404.2
8	$\frac{7}{8}$	8.28	55	55	206.8	196.6
8	$1\frac{5}{16}$	5.48	22	88	548	520.8
8	$1\frac{5}{16}$	5.48	36	74	281.6	267.6
8	$1\frac{5}{16}$	5.48	55	55	137	130.2

Constant $\div$ by twist = Twist Gear.

TABLE OF TWIST CONSTANTS. DRAPER TWISTER.

Diam. of Cylinder.	Diam. of Whirl.	Diam. of Roll.	Gear on Roller.	Stud Gear.	Jack Gear.	Constant.
8	$2\frac{1}{2}$	$1\frac{1}{2}$	90	36	120	197
8	$2\frac{1}{4}$	$1\frac{1}{2}$	90	32	120	245
8	$1\frac{3}{4}$	$1\frac{1}{2}$	90	36	120	275.8
8	$1\frac{1}{4}$	$1\frac{1}{2}$	90	38	120	356.4
8	$1\frac{1}{8}$	$1\frac{1}{2}$	90	32	120	465.6
8	1	$1\frac{1}{2}$	90	28	120	591.2
8	$\frac{7}{8}$	$1\frac{1}{2}$	90	26	120	716.2

NOTE.—The change gear is the one on Cylinder.
Constant $\div$ twist = Twist Gear.

LOWELL AND FALES AND JENKS TWISTERS.

As there are over a hundred combinations used on these frames, we will give only the formula for getting the twist, twist constant, etc.

C—Cylinder gear.
J—Jack gear.
T—Twist gear.
F—Front-roller gear.
R—Relation of cylinder to whirl.
4.7124—Circumference of $1\frac{1}{2}''$ roller.

$$\frac{J \times F \times R}{C \times T \times 4.7124} = \text{Twist per inch.}$$

$$\frac{J \times F \times R}{C \times 4.7124} = \text{Twist Constant.}$$

$$\frac{\text{Twist Constant}}{\text{Twist Gear}} = \text{Twist per inch.}$$

$$\frac{\text{Twist Constant}}{\text{Twist per inch}} = \text{Gear.}$$

In the foregoing tables no allowance is made for contraction in twist, principally because it is such a variable factor. In spinning it is a variable quantity, varying with the numbers and also with the amount of twist. In twisting it becomes more variable. As the twist is put in in the reverse direction in which the single yarn is twisted, part of the twist is taken out and therefore the thread elongates. If the twisting were stopped at this point, the result would be more

yards, and therefore finer yarn than before. This is actually the case in coarse yarns, and in order to get the twisted yarn the correct number, it is necessary to make the single yarn coarser than the number wanted. This elongation, amounting to about 5 per cent with number 4's, gradually diminishes until number 30's is reached, when neither elongation nor contraction takes place. From number 30's contraction begins, and steadily increases until at number 100's it amounts to 4 per cent. It may thus be readily seen that there may be a considerable difference in the production of two mills making twisted yarns. If one is making 20 2-ply, the single yarn may be 19.5, which will make a good deal of difference. On the other hand, another mill making 40 2-ply will have to make, say, 40.5—a considerable difference in the opposite direction.

For many purposes it is not desired to have the yarns of a soft, oozy nature. Yarn twisted on ring frames is much more open than if twisted on mule or throstle frames, on account of the centrifugal force tending to throw the loose ends of the fibers out, and also to some extent by the yarn chafing against the traveller. When an extra-smooth yarn is desired it is passed through a gassing frame, where the projecting fibers are singed off. For most purposes however a wet twist is sufficient. In England, this is usually accomplished by having the roller immersed in

water, but in the United States the yarn is wet by passing it under a glass rod immersed in water. This is a better arrangement, as the rod can be more readily removed, and the water cleaned from the accumulation of lint which will collect, and if not removed be taken up and twisted in the yarn. The English wet twisters frequently have steam pipes in the water to keep it hot. This would seem to be a good idea, as the writer has seen yarn intended for samples greatly improved in appearance by immersing in boiling water.

It is more difficult to run wet twist than dry, and usually the frames must be run at a slower speed or have larger bobbins. On this account, wet twist usually brings a little better price than dry, although no difference is made in the market quotations.

TROUBLES IN RUNNING TWISTERS.

Lean Yarn.—When the writer first began to make two-ply yarn for the market, there was complaint that the yarn, which was 26-2, was "lean." The commission merchant did not seem to have a very clear idea what the term meant, probably simply quoting the comment of the consumer. After a good deal of correspondence it developed that "lean" meant that the yarn did not look right on account of the twist being out of proportion. The commission men never were

able to tell exactly what the trouble was, but the writer has since learned that the term indicates what it would if applied to a person, that is that its diameter is too small. There are two ways in which lean yarn is made. The most frequent cause is having too much twist in the single yarn. It is a fact that nine-tenths of the mills in the South make their yarn for twisting with the regular warp twist. This makes the yarn stronger and more easily handled, but also greatly affects its appearance after being twisted. It is not always practicable to spin the yarn, or rather to spool and twist it, with 2.75 times the square root of the number, but the nearer this standard is approached the better the yarn will be. Contrary to general belief, twist in the single yarn has very little or nothing to do with the strength of the double yarn. This is very easily demonstrated by the fact that spindle bands made from roving are as strong as if made from yarn.

The other cause for lean yarn is too great tension in twisting. This is caused either by fast speed, and the necessity for using a heavy traveller to keep the ends from thrashing together, or it is caused by using a heavy traveller in order to get more yarn on the bobbin. Vertical rings are not well suited for dry twisting, as more tension is put on the yarn. Besides this, the traveller bill will be fully twice as great. For good, lofty yarn the twisting should be with as

little tension as possible. As mentioned in the chapter on ring spinning, ballooning is good for the yarn, provided the ends do not lash together, as it helps to pull the traveller, and for good yarn extra space on a twister is desirable. The writer is familiar with two cases where this was amply demonstrated. One case was where there were three twisters equipped with 3″ rings for number 10 yarn, but were used for twisting number 24. The 3-inch rings were afterwards replaced with 2-inch, a light traveller put on, and a much nicer yarn was made. On account of the light traveller, an end seldom broke, and the twister hands preferred running these frames at 10 cents a side to running the regular 3″ space 2″ ring at 12½ cents. Another case was where looms were put in, and consequently all the twister spindles were not needed. Only every other one was used, a lighter traveller put on, and the yarn brought a better price than it did before.

Single or Double.—These terms are not to be taken literally, but simply mean less and more than the required number of strands. It is hardly necessary to mention the defect, as the remedy is so obvious, viz., closer scrutiny at the twister. Single yarn will not occur in two-ply work, as the reverse twist will cause the end to come down. In coming down, it often engages in the thread next to it, making three-ply, or technically double. In every case the twister hand is not respon-

sible for this, as the writer has seen a thread twist in with another and then break away, leaving nothing to show the attendant that imperfect yarn had been made. The Draper Company has a very simple and effective device for preventing the further delivery of yarn when one end breaks. This applies only in 2-ply work, and does not work well on wet twisters. Single yarn is the night-mare of mills where three-, four- and five-ply is made. If 5-ply is being made, it is almost impossible to detect by a glance that one thread is missing, and only the most trusted employees should be put on such work. The writer has patented a very simple electric device for preventing single on such work. It consists primarily of drop wires, an electric bell and an annunciator. When a thread breaks, the bell rings and keeps ringing until the end is pieced up, the annunciator showing where the broken end is.

Fuzzy Yarn.—This occurs especially in two-ply work where an end breaks down. The yarn on the bobbin continues to revolve rapidly, and the fibers being thrown out by the centrifugal force, are taken up by the threads on each side and twisted in with them. This will not take place except in high-speed work, and there is no way to prevent it. All that can be done is to have the twister-hand examine the bobbins on each side of the broken end and pull off the defective yarn. Separators will prevent the trouble only to a very

limited extent, but they will prevent a great deal of trouble caused by the yarn lashing together and breaking down. They are not often used on twisters, but the writer has never seen a good reason why. On the fine yarn they are certainly as desirable as on spinning frames, and will enable more work to be done per spindle.

Corkscrew Yarn.—This is a very common complaint with twisted yarn. Where two threads of unequal diameter are twisted together, the smaller one will twist around the other instead of both twisting together. This is caused in the spinning-room by one of the many things which go to make up uneven yarn. The chief cause which will show up on the twister is single or double roving, which if the double roving is used on the spinning frame, will make a thread 50 per cent larger than the average. Fluted back top rollers will deliver more roving and make a coarser thread, or fluted front top rollers will cause more draft and make a finer thread. Corkscrew may also be caused by the twist being put in the wrong direction, either in the single or in the double. If in the latter, a very kinky yarn will be made which any novice will detect. A very short length of corkscrew is often caused by clearer waste or flyings being twisted in the yarn, making an inch or two of very coarse yarn.

Long or Dirty Knots.—This is sometimes a great source of complaint. The twister-hands will get

their fingers soiled while cleaning the frame, and if an end breaks piece it up with the inevitable result. On all fine work the operatives should be provided with scissors and carefully cut off all long ends. They should also be required to keep their hands clean.

Slack Twisted Yarn.—It sometimes happens that different frames have different combinations of gears, and occasionally one will be putting in 25 per cent more or less twist than it should. Slack bands of course are the source of most of the trouble. They should receive more attention than bands on the spinning frame, for the results are more serious. In some mills the twister-hands put on the bands. This is a bad method, as they have neither time nor the judgment necessary. There should be a reliable man whose duty is to look after the twisters and reels, and who should examine every band at least twice a week, and oftener if there are changes in the weather. The reelers, who can tell a slack twisted bobbin by its spongy nature, should be trained to put them to one side. In some mills these are twisted again, and in others they are all reeled together and the yarn put aside until a bale has accumulated. For some purposes soft twist is desirable, and an occasional bale can be sold at the regular price. Warp yarn should be more evenly twisted than skein yarn. Much of it goes into worsted cloth, which is woven with

a twill effect. A slack-twisted thread will show very plainly in some weaves, making what is known as "railroads" in the cloth. Every mill making twisted yarn for the market should have a machine for counting twist.

GENERAL INFORMATION.

Twisters occupy about the same space as spinning frames. Their width is usually 36 inches, but may be 39. The length may be obtained by multiplying the space by half the number of spindles, and adding two feet. The weight is a little more than for spinning frames. The cost is about the same as for spinning frames of equal size rings, but as twister rings are always larger for any particular number of yarn, the cost is from 25 cents to 50 cents more per spindle. On two-ply work, it usually requires one twister spindle to take care of two producing spindles. On three- and four-ply work, no such general proportion will hold good, but the required number must be calculated from the production tables.

The power required for twisters is in excess of that for spindle frames. It varies greatly with the size of rings and the character of work. On two-ply work number 24 yarn, about 45 spindles will absorb a horse power. The pulleys should not be less than 3-inch face and 12 inches diameter, and even a larger diameter is often desirable.

The wind on a twister may be either warp or

filling, or a combination. The writer prefers a filling or cone wind, except perhaps for the largest rings. The yarn is more readily reeled, and the bobbins having no head, last much longer.

REELS.

In spinning mills, of which there are a large number in the South, especially in North Carolina, a large part of the product is reeled, often all of it. Single yarn is usually reeled in skeins of one or two bobbins regardless of any particular weight. There is not nearly so much single yarn reeled as there was a few years ago. Much of it being coned, and much of the filling yarn is being run in filling warps to be dyed and afterwards quilled. Ply yarn is generally reeled in skeins of a certain weight, 24-2 being put up in $2\frac{1}{2}$ or- 3-ounce skeins, 8-3 in 12-ounce, etc. Sometimes it is necessary to have the weight exact, as the skeins are dyed and sold to the retail trade. When this is the case, a motion must be put on the reel to stop it when a certain length has been wound. Ordinarily, the bobbins can be shaped so that they will hold about the right weight, or some multiple of it. A quarter of an ounce more or less is not usually objected to.

Reels are sometimes made so as to twist 2-, 3- or 4-ply as the yarn is being reeled. This is done by having a 2-, 3- or 4-pronged spindle to hold the bobbins, and as the reel turns, this spindle re-

volves. The objection to this method is that it is very hard to tell when one of the threads break, and single is made. We know of a good many such reels being discarded as unsatisfactory, but also know of two mills, one of them a large one, which have used them for many years. Reels are made for running 54″, 60″, 72″ and 90″ skeins, Fine yarns are generally reeled 54″, medium 72″, and very coarse ply yarns 72″ and 90″.

The production of a reel does not depend so much on the size of the skein as one would naturally suppose, as the speed is governed largely by what the machine will stand and the speed at which bobbins can be unwound. If live spindles, or the ones which revolve with the bobbins, are used, an excessive vibration and tension is caused by high speed. If a dead spindle is used, and the yarn pulled over the top, high speed causes the ends to whip together and break down. The writer has used separators on reels very successfully, but has never seen them sent out from the shop. He has also found it advantageous to space the spindles further apart than they are generally made. For medium yarns they are generally spaced $2\frac{3}{4}''$, but a greater production can be had with a 3″ space.

REEL PRODUCTION TABLE, 10 HOURS.

No. of Yarn.	54 Inch Reel.				60 Inch Reel.			
	120 Rev.	130 Rev.	140 Rev.	150 Rev.	120 Rev.	130 Rev.	140 Rev.	150 Rev.
4	12.8	13.8	14.8	16.0	14.0	15.2	16.3	17.5
5	10.2	11.0	12.0	12.7	11.4	12.2	13.3	13.7
6	8.5	9.2	10.0	10.6	9.4	10.2	11.0	11.3
7	7.3	7.9	8.4	9.1	8.0	8.8	9.3	10.0
8	6.4	6.9	7.4	7.7	7.0	7.6	8.1	8.8
9	5.4	5.8	6.6	6.7	6.2	6.8	7.2	7.7
10	5.1	5.5	6.0	6.4	5.7	6.1	6.6	7.1
11	4.6	5.0	5.4	5.7	5.1	5.6	5.9	6.4
12	4.2	4.6	5.0	5.2	4.7	5.1	5.5	5.9
13	3.9	4.2	4.6	4.8	4.3	4.7	5.0	5.4
14	3.6	3.9	4.2	4.5	4.0	4.4	4.7	5.0
15	3.4	3.7	4.0	4.2	3.8	4.1	4.4	4.7
16	3.2	3.4	3.7	4.0	3.5	3.8	4.1	4.4
17	3.0	3.1	3.5	3.7	3.3	3.6	3.8	4.1
18	2.8	3.0	3.3	3.5	3 1	3.4	3 6	3.9
19	2.7	2.9	3.1	3.4	3.0	3.2	3.5	3.8
20	2.5	2.7	3.0	3.1	2.8	3.0	3.3	3.5
21	2.4	2.6	2.8	3.0	2.7	2.9	3.1	3.4
22	2.3	2.5	2.7	2.8	2.5	2.8	2.9	3.1
23	2.2	2.4	2.6	2.7	2.4	2.6	2.8	3.0
24	2.1	2.3	2.4	2.6	2.3	2.5	2.7	2.9
25	2.0	2.2	2.4	2.5	2.2	2.4	2.6	2.7
26	1.9	2.1	2 3	2.4	2.1	2.3	2.4	2.6
27	1.9	2.0	2.2	2.3	2.1	2.2	2.4	2.6
28	1.8	1.9	2.1	2.2	2.0	2.1	2.3	2.5
29	1.7	1.8	2.0	2.1	1.9	2.0	2.2	2.4
30	1.6	1.7	1.9	2.0	1.8	2.0	2.1	2.2
40	1.2	1.3	1.5	1.7	1.4	1.5	1 6	1.8
50	1 0	1.1	1.2	1.4	1.1	1.2	1.3	1.4
60	.8	.9	1.0	1.2	1.0	1.1	1.2	1.3

Sixty per cent of the time is allowed for stops.

REEL PRODUCTION TABLE, 10 HOURS.

No. of Yarn.	72 Inch Reel.				90 Inch Reel.			
	110 Rev.	120 Rev.	130 Rev.	140 Rev.	100 Rev.	110 Rev.	120 Rev.	130 Rev.
4	15.6	16.8	18.4	21.0	17.6	19.2	21.2	22.4
5	12.5	13.6	14.8	16.0	14.2	15.6	17.0	18.1
6	10.4	11.2	12.2	13.2	11.8	13.0	14.2	15.4
7	8.8	9.6	10.4	11.2	10.0	11.2	12.2	13.2
8	7.8	8.4	9.2	10.0	8.8	9.6	10.6	11.6
9	7.2	7.6	8.2	8.8	7.8	8.6	9.4	10.1
10	6.2	6.8	7.4	8.6	7.1	7.8	8.5	9.2
11	5.6	6.2	6.7	7.2	6.4	7.1	7.7	8.4
12	5.2	5.6	6.1	6.6	5.9	6.5	7.1	7.7
13	4.8	5.2	5.6	6.1	5.4	6.0	6.5	7.1
14	4.4	4.8	5.2	5.6	5.0	5.6	6.1	6.6
15	4.1	4.5	4.9	5.3	4.7	5.2	5.6	6.1
16	3.9	4.2	4.6	5.0	4.4	4.8	5.3	5.8
17	3.6	4.0	4.3	4.6	4.2	4.6	5.0	5.4
18	3.4	3.8	4.1	4.4	3.9	4.3	4.7	5.1
19	3.2	3.6	3.8	4.2	3.7	4.1	4.4	4.8
20	3.1	3.4	3.6	4.0	3.5	3.9	4.2	4.6
21	2.9	3.2	3.5	3.8	3.4	3.7	4.0	4.4
22	2.8	3.1	3.3	3.6	3.2	3.5	3.8	4.2
23	2.7	2.9	3.2	3.4	3.0	3.4	3.7	4.0
24	2.6	2.8	3.0	3.3	2.9	3.2	3.5	3.8
25	2.4	2.7	2.9	3.2	2.8	3.1	3.4	3.6
26	2.4	2.6	2.8	3.0	2.7	3.0	3.2	3.5
27	2.3	2.5	2.7	2.9	2.6	2.8	3.1	3.4
28	2.2	2.4	2.6	2.8	2.5	2.7	3.0	3.3
29	2.1	2.3	2.5	2.7	2.4	2.6	2.9	3.2
30	2.0	2.2	2.4	2.6	2.3	2.5	2.8	3.0
40	1.5	1.6	1.8	2.0	1.7	1.9	2.1	2.3
50	1.2	1.3	1.4	1.6	1.4	1.5	1.6	1.8
60	1.0	1.1	1.2	1.3	1.1	1.2	1.4	1.5

Sixty per cent of the time is allowed for stops.

TROUBLES IN REELING.

Loose Ends.—All reeled yarn should be rigorously inspected. It is much more important than at any other point in the process of manufacture, because all the work has been put on the goods, making them, on the whole, of a good or even superior quality, and a few bad skeins may spoil a large shipment. The writer once had charge of a mill where they had a great deal of complaint and several claims on what was called "cut yarn." Investigation showed that the skeins were made from the yarn of two bobbins, and where the reelers could not readily find the end of the first bobbin to which to tie the second, they would simply twist the ends on the yarn and go ahead. In winding, it came in two at this point, and the consumer reported it "cut."

Tangled Skeins.—This may be caused by tying the under end of one skein to the upper end of the next, and when the reeler starts this way, the whole doff will be tied together. Another way of tangling skeins is to allow the traverse motion to get out of fix. A very small skein, or very coarse ply yarn, may sometimes pass inspection without being cross reeled, but on the whole it is apt to cause trouble. It would seem unnecessary to call attention to such a self-evident fact, but we once knew of over 100 bales of yarn being condemned on account of one reel out of five being out of fix. At the time the yarn was sold for 25

cents a pound, but this lot was finally disposed of at 18 cents.

Black Oil.—This may get on the yarn before it is reeled, but with the most careful reelers the skeins occasionally get black. If the yarn is very valuable, it will often pay to lay aside these skeins until enough accumulate, and wash out the black spots. This can usually be done with soap and warm water, but if not, oxalic acid will greatly assist. On no account should this blackened yarn be allowed to go in with the regular quality.

Slack twist, double, single, corkscrew and other imperfect yarn should all be removed by the inspector.

Packing.—Some mills simply loop a skein through a dozen or more and bale them in mass. Such a careless method can not fail to affect the value of the goods, for neatly packed goods always bring the best class of customers. On the inspector's table a rack should be made of standards about 18″ long. From three to six skeins are then twisted together and laid in this rack. When it is full, the whole is tied together in two or three places, making a neat bundle which looks well and facilitates handling. The yarn for tying is slack or imperfect yarn, which is good for nothing else. In a month several hundred pounds of this can be used up and sold at the regular price.

GENERAL INFORMATION.

A reel should not be more than 15 feet long. If the spindles are spaced 3 inches apart, there will then be 50 spindles. A 54-inch reel is about 2 ft. 4 in. wide, a 60-inch 2 ft. 10 in., and a 90-inch 3 ft. 8 in. They cost according to space and the number of spindles. With 50 spindles and 3-inch space, one will cost about $90.00.

A prominent English builder makes reels with four swifts, two on each side, holding 10 skeins each, and running independent of each other. This makes a gain of at least 25 per cent in production, as the operative is tying off or doffing one skiff while the others are running. Reels are also built in England having a stop motion for each thread. Under certain conditions the English law requires that each skein be of equal length.

CHAPTER VIII.

WARPERS.

Warpers may be divided into three classes: ball warpers, beam warpers, and chain warpers. Ball and beam warpers are nearly alike in construction, but chain warpers are not. One style, now almost out of use, winds the yarn in the form of a loose rope around a frame of large diameter. This is known as a circular warping mill or reel warper. Another style is known as a Denn warper, and another retains some of the features of the Denn warper, but without the electric stop motion.

As the beam warper, often known as the slasher, or section warper, is the most frequently used, we will consider it first.

In order to have good work at the loom, it is absolutely necessary to have beams with continuous ends. Where there are from 400 to 500 spools, some of the threads are sure to break, and if not detected quickly and tied up, they will be lacking on the loom beam. There are two methods used to detect a broken end. One a mechanical one by means of drop wires, and the other also by means of drop wires, but with the stop motion operated by electricity. Under favorable conditions both will work well, but as the electric de-

vice gives a better chance for the machine to be stopped before the broken thread reaches the beam, it is preferred by a great many. On the other hand, electricity is but little understood by mill people in general, and it is claimed that it complicates matters, and makes the machine more difficult to fix.

CALCULATIONS.

About the only calculation about a warper is to ascertain the weight of yarn on the beam. Of course this is readily done by deducting the weight of the empty beam from that of the full one. It is desirable, however, for a superintendent to know what the beam ought to weigh as well as what it does weigh. He will not only know how closely the required numbers are being spun, but will also be enabled to better regulate the weight of cloth by making slight changes in the filling. A record should always be kept of the net weight of every beam, and by a very simple calculation the average number of yarn on every set for the slasher can be known and recorded.

All warpers have a measuring device, driven by a measuring roller, which turns one time for every one-quarter yard which passes over it. By means of worms and gears this motion is reduced so that from 2,000 to 3,000 yards, generally 3,000, have been run when the machine stops. This

amount of yarn is called a wrap. The beam may hold 6, 8 or 10 wraps, according to the number of yarn and the size of beam. If we know the number of yards in a wrap, and the number of ends, we can calculate the weight of yarn.

Rule.—*Multiply the number of yards in a wrap by the number of wraps and the number of ends, and divide by 840 multiplied by the number of yarn.*

Example.—Number of ends 480; number of yarn 20; number of yards on wrap 3,000; number of wraps 5; what is the weight of yarn on beam?

$$\frac{3000 \times 5 \times 480}{840 \times 20} = 428.5$$

It takes about 60 cubic inches to hold a pound of yarn. To find the cubic inches, we first find the number of square inches in a cross section, or a circle of the required diameter. This is done by multiplying the square of the radius (half of the diameter) by 3.1416. After getting the area of the circle, we must subtract the area of the circle represented by the barrel, and then multiply by the length between the heads.

Example.—Diameter of head 26″; diameter of barrel 9″; length between heads $54\frac{1}{4}$″; what is the number of cubic inches, and what will a full beam weigh?

$(13)^2 = 169$
$169 \times 3.1416 = 530.93$
$(4\frac{1}{2})^2 = 20.25$
$20.25 \times 3.1416 = 63.61$
$530.93 - 63.61 = 467.32$
$467.32 \times 54\frac{1}{4} = 25352 =$ Number of square inches.
$25352 \div 60 = 432$ pounds.

The beams have a barrel 9″ in diameter, and are $54\frac{1}{4}$″ between heads. A full beam, of the following dimensions, will weigh as follows:

26″ head, for yarns up to	20's	430 pounds.
24″ head, " "	30's	360 "
22″ head, " "	40's	293 "
21″ head, " "	50's	260 "
20″ head, " "	100's	226 "

These results are only approximately correct. The weight will vary with the size of the spool, number of yarn, number of ends and speed of machine.

TROUBLES IN RUNNING WARPERS.

Unequal Lengths.—It is probable that this is the chief trouble in the warping department. The writer has run across it in a number of mills. In every case it is not the fault of this department, but is sometimes due to unequal tension on the beams at the slasher. Where this is not the case, it is usually due to a very slight variation in the diameter of the measuring rollers. The variation of only 1-100 of an inch will make a vast difference in the total length of the yarn, for the roller turns four times for each yard, and

on many beams there are 24,000 yards, multiplying the error 96,000 times. Assuming that the beam has 8 wraps, or 24,000 yards, this variation would amount to 91 yards, and even half this would occasion a big loss. Where this variation exists, it can usually be remedied by putting on one or more coats of paint. If this is not the trouble, it may be due to friction or lack of oil in the measuring roller, or some of the connecting mechanism. It is also occasionally caused by end play of the rollers, or by the rollers not running true.

Excessive Breaking of Ends.—This is often caused by bad spooling. Some time ago, the writer had occasion to investigate very carefully the operation of eight machines. He found that the spools were not marked, so that bad work could not be traced to one who made it. After a system of marking was inaugurated, the number of breakages was reduced from an average of 130 per beam to 89. A careful record was then kept, and it was found that of the total number of breaks, 20 per cent were caused by bad spooling, 11 per cent by rough spools, and 69 per cent from unknown causes. Of the latter, probably a large number were caused by ends being lapped at the spooler, and also by excessive speed. While the machine builder recommended a maximum speed of 218, and a minimum of 163, these machines were running at 225. On one of them the

speed was reduced to 172, and a careful comparison was made. The average number of breaks on the other machine was 89, and on this machine 68, a decrease of 23 per cent. While the speed was reduced nearly 24 per cent, the time required to run a beam was increased only 9 per cent. While the number of breaks is a fair indication of the quality of work done, the benefit to the weaving is certainly in an increased proportion, on account of less elasticity being taken from the yarn. These same beams taken to the slasher showed 27 per cent less breaks than the average, a per cent slightly in excess of the gain on the warper.

There was not sufficient time to follow the test on the looms, but as they were Northrop looms, and therefore most of the weaver's time taken up repairing warps, a saving of 27 per cent would mean a much greater production. These experiments certainly show that fast speed is not only very injurious to the yarn, but also to a great extent defeats the end for which it was intended, viz., greater production.

The Draper warper is driven by cones, so that the machine runs slower as the spools become empty. Sometimes in their zeal to finish the beam quickly, the operatives will keep the machine on the high speed throughout the entire set. This emphasizes the fact that the belt-shifting device should be carefully watched.

Selvage Piled Up.—There is no occasion for this, except when the selvage threads are two-ply, when the operative will sometimes space them the same as for single yarn. If they are spaced one thread in two dents and watched carefully, the beam will be the same diameter all the way across, which is absolutely necessary for good work.

Prodution.—As much time is lost while creeling, and also more or less while piecing up ends, only about two-thirds of the theoretical production should be counted. Most warpers have an 18-inch cylinder, but some have a 12-inch. In the following table the production is based on two-thirds of the theoretical production, and is given for each 100 spools in the creel.

PRODUCTION TABLE, BEAM WARPER PER 100 SPOOLS.

Rev. of Cyl.	30		33		36		40	
No. of Yarn.	12″	18″	12″	18″	12″	18″	12″	18″
8	198	297	218	327	247	380	264	......
10	161	241	176	264	193	289	215	......
12	130	195	143	214	156	234	173	......
14	115	172	126	189	138	207	153	......
16	101	151	110	165	121	181	135	......
18	96	135	98	147	108	162	120	......
20	80	120	88	132	96	144	106	......
22	73	109	80	120	88	132	97	......
24	66	99	72	108	79	118	89	......
26	62	93	68	102	74	111	83	......
28	57	85	62	93	68	102	76	......
30	53	79	59	88	63	94	71	......
32	50	75	55	82	60	90	66	......
34	47	70	52	78	56	84	62	......
36	44	66	48	72	53	79	58	......
38	40	60	44	66	48	72	53	......
40	39	58	43	65	47	70	52	......
42	38	57	42	63	46	69	51	......
44	36	54	39	58	43	64	48	......
46	35	52	38	57	42	63	47	......
48	34	51	37	55	41	61	45	......
50	32	48	35	52	38	57	42	......

NOTE—33 per cent of the time is allowed for stops.

GENERAL INFORMATION.

A warper with a creel for 500 spool occupies a space of about 9 × 16 feet, and costs $250.00. If there are only one or two machines, 15 or 20 beams will be required. These are extra, and cost $10.00 each. The machine with one empty beam weighs about 6 pounds per spool, or 3,000 pounds for a 500-spool machine. The horse-power required is about one-quarter. The operative, if others do the creeling, can attend to from two to six machines. If the spooler-hands do the creeling, which is often the case in small mills, one warper is usually required for each spooler of a hundred spindles.

THE DENN WARPER.

Where the warp yarn is not used in the same mill where it is spun, or where it is to be bleached or dyed, the yarn is not warped on a beam warper, but on a chain warper, the most usual form of which is the Denn warper, so-called from the inventor. A distinctive feature it has from other machines is the electric stop motion and an improved linking device. Where a warp is required with only a few ends, or for special purposes, a ball warper is used, which is practically the same as a beam warper, except it has a leasing device and winds on wooden or paper cylinders instead of beams. A Denn warper may

also have an attachment, or several of them, for balling warps.

Calculations.—Warps are sold by the pound, but the weight is determined by calculation and not by weighing. It is therefore desirable that the actual weight and the theoretical weight correspond within reasonable limits. If the warp weighs more than it should, the mill loses that much cotton. On the other hand, if it is too light the purchaser is paying for more than he receives. About three per cent either way is not considered excessive, but the mill always tries to make it on the light side. Sometimes a mill finds its yarn too heavy or too light, and in order to make the warp weigh correctly, the attendant makes it a few yards longer or shorter than the required length. This is an exceedingly bad practice. One warp may be dyed red, and a part of it be put in with a blue stripe from some other warp. If they are not of equal length, there is considerable waste at the beamer. The method of calculating the weight is the same as for the beam warper, the only difference being a larger number of ends.

Example.—Number of ends 1,600; number of yards 4,000; number of yarn 30; what is the weight of the warp?

$$\frac{1600 \times 4000}{840 \times 30} = 253.9 \text{ pounds.}$$

If the yarn were two-ply, as it frequently is, the actual number would be 15 instead of 30, and the warps would be twice as heavy.

Warps are usually ordered with so many cuts of a definite number of yards each. The apparatus for measuring the length is a simple train of gears very much like that on a beam warper. The measuring roll is 8 inches in diameter, or more exactly, 24 inches in circumference, and is driven at three times the speed of main shaft, so that 8 inches of yarn are delivered for each revolution of the driving shaft; or to express it in another way, the driving shaft must turn $4\frac{1}{2}$ times for each yard in the cut. The problem then is to get a train of gears so that the pin wheel, or the disk on which is a pin for striking the bell, revolves one time for the required number of yards. Let us take the gears as follows:

Worm = 1
Worm gear = 81.
Small gear on worm shaft ——
Large gear on pin wheel = 85.
Required number of yards in cut = 51.

What change gear will be required?

$$\frac{81 \times 85}{4\frac{1}{2} \times 1 \times 51} = \text{Change gear.}$$

This works out 30, which is the gear required. It frequently happens that it does not work out an even number of teeth, in which case one of the other gears must be changed, and the only way

to do is to keep trying until we get the required combination.*

PRODUCTION.

The driving shaft generally runs from 150 to 200 revolutions per minute, and as it takes $4\frac{1}{2}$ revolutions to make a yard, the theoretical production is readily calculated. It takes a long time to creel a warper and some time to take leases and piece up broken ends, so that 60 per cent of the theoretical production is about what can be expected. This should increase somewhat with finer yarn.

PRODUCTION OF DENN WARPER PER 100 SPOOLS.

Number of Yarn.	Speed of Shaft.					
	150	160	170	180	190	200
8	178	190	202	213	225	237
10	142	152	161	173	181	189
12	119	127	134	143	150	158
14	102	109	115	122	129	136
16	89	95	101	107	112	118
18	79	84	89	95	100	105
20	71	76	80	85	90	95
22	65	69	73	78	82	87
24	59	63	67	71	74	78
26	55	58	62	66	70	73
28	51	54	57	61	64	68
30	47	50	53	56	59	62
32	44	47	50	53	55	58
34	42	44	47	50	52	55
36	39	42	44	47	49	52
38	37	40	42	44	46	49
40	35	38	40	42	44	47
42	33	36	38	40	42	44
44	32	34	36	38	40	42
46	31	33	35	37	39	41
48	29	31	33	35	37	38
50	27	30	32	34	35	36

*The publishers of this work are prepared to furnish, at $1.00 per copy, a book containing every possible combination of gears for making changes in the length of the cut. There are over 1,000 changes given and the overseer can tell at a glance the proper gears for any length of cut desired. No one who uses a Denn warper can afford to be without it.

TROUBLES IN WARPING.

Stop Motion Not Acting.—The electric apparatus is very simple and not likely to get out of fix. If only one section fails to act, it is evidence that a connection is broken and the wires should be carefully examined. If none of the sections act, try the bell to see if there is any current. If there is, one of the main connections is loose. If there is not, it is probable that oil is on the end of the commutator, or that the spring is not tight against it.

Slack Ends.—Sometimes a complaint comes in that one side of the warp is slack, or it is sometimes expressed that the warp has been rolled. This is caused by the trumpet not being in the center of the creel. It may also be caused by a thread wrapping around one of the rollers until the top roller is lifted off the warp and weakens the draft. When it does occur it is a very serious defect, and should be looked after carefully.

Tight Water Bands.—Warps run on the Denn warper are usually dyed, and if the water bands are tied tight they prevent the dye from penetrating freely and make a bad place in the warp. For the same reason, it is sometimes desired that cut mark bands be tied tight so as to mark the cut, but in the absence of any specifications to that effect they should also be tied slack, but so as not to slip their position.

Broken Ends.—Under ordinary conditions the machine will stop before the broken end has gone through the eye-board. Often it does not, and the careful warper hand will use every effort to find the broken end and piece it up. At this point lies the principal difference between a good and bad hand. Loose ends very seriously interfere with beaming and weaving, and although no special complaint may be heard for a long time, when another order is made it will have considerable bearing on the matter. The question of a few cents a day should not be sufficient inducement to change a man who is known to be careful and efficient. Several hundred dollars worth of damage may done before any complaint is heard from the consumer. There is probably no place in the mill where a carfeul hand is more necessary.

GENERAL INFORMATION.

The Denn warper is made with creels for from a thousand to four thousand ends. It is very doubtful if it pays to have them with more than two thousand, as one thread breaking will then stop so many spools. It is true the first cost is less, but ths is a small matter when compared with the cost of production. Machines are made with one, two and sometimes three heads. These of course must be run together, but may have different kinds of yarn and different lengths of

cuts. The machine may be arranged to ring a bell at every cut so that the band boy may tie a cut band, or the cut may be marked on the warp with a colored fluid.

A Denn warper occupies a space of from 16 to 24 feet wide, and from 36 to 40 feet long. When long machines are used, or indeed any of them, the warper-hand should be required to creel the spools first that are furthest from the machine, then run a few feet and creel more. By this method the waste may be reduced from 12 to 15 yards to about 2. They will not do this unless they are required to, as it is a little more trouble.

The machine costs from $800.00 to $1,800.00, according to the number of spools.

The quality of the yarn may be improved by causing the warp to pass through a brush. The amount of trash knocked off will surprise any one who has never seen it tried.

CONE WINDERS.

Cone winders are much more generally used than they were a few years ago. For hosiery yarn and for many other purposes, the yarn was formerly used direct from the cops or from spools. In England cone winders are known as quick traverse winding frames, as opposed to spoolers or slow traverse winding frames. This name would seem to be a better one, as the ma-

chine not only winds cones but other shapes as well.

Cops are much better to wind from than spinning bobbins, not only on account of the longer lengths of yarn, but also on account of there being less waste. Where the filling wind is used, the doffers in threading-up frequently start the wind half way up the bobbin, and when the yarn reaches this point it is almost sure to break, and what remains is cut off as waste. This is of course true in the loom also, but not to as great an extent, as the speed of unwinding is much slower. Warp wind bobbins will not work on a cone winder on account of the variable speed at the large and small end of the cone. If tubes are being wound, the warp bobbins are preferable.

PRODUCTION.

There are three makes of machines on the market, the Foster, the Broadbent and the Universal. The Foster is the one most frequently used, and on which we will base the production. The Universal gives a production of from 50 to 75 per cent more than the others, but costs a great deal more. In general terms a drum may be said to produce about the same as a spooler spindle, or to take care of from 15 to 20 spinning spindles.

The following table gives the production per drum for 10 hours, the fastest speed being the one most frequently used.

PRODUCTION OF CONE WINDERS. 10 HOURS

No. of Yarn.	28 Gear.	26 Gear.	24 Gear.	No. of Yarn.	28 Gear.	26 Gear.	24 Gear.
4	19.04	21.60	23.32	24	4.04	4.52	5.08
6	15.49	17.16	18.86	26	3.86	4.22	4,74
8	11.94	12.72	14.30	28	3.50	3.92	4.40
10	9.50	10.18	11.40	30	3.24	3.62	4.07
12	7.56	8.48	9.54	32	3.05	3.41	3.88
14	6.51	7.27	8,18	34	2.86	3.20	3.60
16	5,69	6.36	7.15	38	2.71	3.04	3.41
18	5.27	5.89	6.63	38	2.57	2.88	3.23
20	4.86	5.43	7.11	40	2.43	2.72	3.05
22	4.41	4.93	5.55	50	1.90	2.02	2.25

TROUBLES IN RUNNING CONE WINDERS.

Kinks.—Perhaps no trouble connected with the manufacture of hosiery yarn is so common as this. On many knitting machines a kink will break the needles and sometimes an entire set. Where mule-spun yarn is used, it should be steamed about half an hour before using. Where the yarn is spun on bobbins, it is not practicable to steam it, even though enamel bobbins are used. It is true it is frequently done, but at the expense of a great many ruined bobbins. Simply sprinkling cold water on the yarn is not sufficient. It should be sprinkled and allowed to remain in a damp room at least twenty-four hours and longer if possible. A heavy damp cloth laid over the box will greatly help matters. This of course applies to fine yarn. Coarse yarn does not have so much twist and may usually be coned without dampening. As in spooling, the

operative must take up the slack after tying a knot, or kinks are almost sure to be formed.

Twist.—The subject of kinks naturally brings up that of twist. Except for special purposes, coned yarn is desired as soft as can readily be handled. In order to have it soft, if spun on the spinning frame, it is necessary to reduce the speed very materially. It is impossible to keep up the ends if the spindles are running as fast as for warp yarn. The overseer must remember also that when the yarn is pulled off the end of the bobbin, from $\frac{1}{2}$ to $1\frac{1}{2}$ turns per inch are put in in addition to what is made in spinning. Occasionally overseers put in the reverse twist, claiming that pulling over the end will then take out twist instead of putting it in. This is a mistaken idea. It is true that the yarn is twisted the opposite way, but it is also wound the opposite way, and the effect is the same.

Yarn Slipping.—This is a trouble often remedied by wetting the shell. This is an exceedingly bad practice, as the water softens the starch in the paper and causes the yarn to stick to it. The trouble is generally caused either by the shell not fitting the arbor properly, the drum not being oiled, or the cone not being parallel with the drum. (The nose of the cone should be slightly lower than the butt.) It is also caused by slack bands and insufficient friction on the yoke. On

the Foster machine it is frequently caused by the leather on the friction roll being worn.

Overshots or Flotes.—There are a great many causes for these, probably the most common being that the operative fails to take up the slack after tying a knot. Other causes are the yoke having too much side play, the arbor too short, the guide loose or broken, the dogs working loose or failing to strike the cushion exactly together, the guide rods being loose, or the rubber cushion being worn or improperly set.

On the Foster machine they are caused by the drum or drum shaft being loose, the dog hole in the guide being worn, the guide springs being broken, closed too much or choked with waste, or the grooves on drum being worn. On the old style guide with V-shaped openings, the nose being too high will also cause them.

Cones Not Stopping.—It is very essential that the cones stop when the cop or bobbin runs empty. Sometimes they fail to stop on account of the drop wires being too light, or the first bend being so far out that the wire rests on a balance. If the drop wire is open too much it may stick to the flannel rail. The trouble may also be caused by the knock-off ratchet wheel being loose or improperly set, the lever not being set far enough in to allow the frog to reach the notch on lever, the frog slipping to one side, the friction roll being set too close to the drums, the drop wires

bent sidewise, or the pin which holds the frog in position working out.

Knots.—Bad knots are one of the worst defects in hosiery yarn. In many mills it is the custom for the man in charge to re-wind a cone each day from every machine, carefully looking for long knots and other defects. As most of the work is not exposed, there seems no other way of being sure it is well done. Some mills require the cone winders to tie weaver's knots, and some have tried the mechanical knotter, but with indifferent success. If a knot has long ends it is liable to break the knitting needles, or if it does not, will break the yarn. One great trouble is that many operatives do not break off the end of the yarn before tying the knot. The end being free, a large part of the twist is out and the yarn consequently weak. When the knot reaches the knitting machine, the yarn breaks and the blame is laid on the knot, when in fact it is due to the method of tying it.

GENERAL INFORMATION.

The Foster cone winder usually has 100 drums, but may have 80, 60 or 40. A 100-drum machine occupies a space of 30 by 4 feet, and costs $1,000, or $10 per drum. The shorter machines cost somewhat more in proportion, an 80-drum machine being $865.00, and a 60 $695.00. The Universal machine is not sold outright, but is leased

for life at $70 per drum. In the matter of production, and in some other respects, it is superior to the other makes, but there is a question as to whether or not it is worth the difference in price.

Cone winders are built to wind from one to six threads for twisters, and are also built to wind tubes with a taper at each end for hard-twisted or polished thread.

The cost of coning yarn is somewhat higher than for spooling, not because an operative can spool more, but because the spooler requires less attention from the overseer or section hand. It is customary to allow 2 per cent for the value of the cones, but nothing for the wooden cases in which the cones are packed. The allowance of 2 per cent will usually more than cover the cost of the cones, but taking the packing, extra freight, etc., into consideration, the yarn can not be marketed as cheaply as warps or skeins, and usually brings about 1 per cent more per pound. A few years ago the difference was much greater, but like many other paying investments, the business was quickly overcrowded, over thirty mills equipped for making hosiery yarn being erected in two years.

CHAPTER IX.

THE MANUFACTURE OF FINE YARN.

Selecting Cotton.—In this class of work it is more necessary to exercise care than for ordinary numbers. If possible, the bales should be selected which have a very uniform length of staple. These should be mixed well so as to get a portion from many bales in each armful. This same precaution is mentioned in a previous chapter as being desirable for any grade of work, but for fine work it is absolutely necessary. When the cotton is started through the opener, it should be examined closely to see if it is curled as it leaves the feed roll. If it is, there will certainly be trouble in the subsequent processes. To prevent it from being curled and knotted the speed of the beater must be reduced to say, about 1,200 revolutions per minute, at the same time keeping the fan up to the usual speed. The cages, screens and dust flues must be cleaned out thoroughly so as to keep the draft open. The weight must be medium. If anything seems to be going wrong the machine must be stopped, and the trouble located. If this is not done, there will be trouble and worry in the succeeding processes.

Pickers.—The intermediate picker should not be used. Long -staple cotton will not stand the

same amount of beating as ordinary cotton. In order to make this clear we will examine into the process a little more closely. Suppose we are running $1\frac{1}{8}$-inch cotton, and that the beater is making 1,500 revolutions per minute, there being two blades, the cotton would be struck 3,000 times. In the meantime the feed roller, which is 2 inches in diameter, has turned 21 times, and has delivered 132 inches to the beaters. Thus, each inch has been struck $3{,}000 \div 132 = 22.7$ times. If the staple were 1 inch, each fibre would be struck on an average of 22.7 times, but as it is $1\frac{1}{8}$ inch, it will be struck 25.5 times. A similar calculation will show that for $1\frac{1}{4}$-inch cotton each fibre will be struck 39.7 times. This is more than long-staple cotton will stand. A great many of the fibres will be broken, and many more will be curled. For this reason, we not only omit the intermediate picker, but also reduce the speed of the finisher to 1,200 revolutions. As in the opener, the speed of the fan must not be reduced, and extra care taken to maintain a free draft. If this is not done the cotton will be curled. If, however, the fan is speeded too high, the selvages will be bad. This will not work well, and we know of a mill which put in new sides for the lap-head and for the table, thinking that by reducing the space they would get more even selvages. All the machine needed was to have cages,

screens and dust boxes thoroughly cleaned. This should be attended to twice every day.

Carding.—In order to get good carding, the clothing should be of the best quality, fine wire and a good many points to the inch. If the mill is a new one and built especially for fine work, the builders will see that the card has the proper clothing. The cylinder should run 120 revolutions, or at most 130, instead of 165 as for ordinary work. The doffer should not run over 8 or 10 turns per minute. The speed of the licker-in should be reduced to about 225. The feed roll should be drawn off to make it accommodate the long cotton. If this is not done, some of the cotton will be knotted and it will be impossible to straighten it out again. Some builders have a feed plate designed especially for long cotton. The screens and mote knives may be set as usual. The top flats may be set at .005 and the doffer at .006, provided the floor is sufficiently solid. When the floor is not solid, it is impossible to set cards as close as they should be. The card should be very carefully ground, and ground frequently, but not long at a time. More waste will be produced than from ordinary cotton, and for this reason the cards must be stripped more often. They should not all be stripped at one time, but every other one only. In about an hour the rest may be stripped. The help will not like this arrangement, but it makes more even work.

Everything must be kept scrupulously clean, and occasionally the screens should be taken out and polished.

By actual test, the following results were obtained from carding 16,808 pounds of cotton, put through 40 cards:

Strippings	907 pounds =	5.39 per cent.
Flyings	298 pounds =	1.77 per cent.
Sweepings	88 pounds =	.53 per cent.
Card drawing	15,525 pounds =	92.31 per cent.

The total waste was 7.69 per cent, which is considerably more than is usually taken from ordinary cotton. This test was on Peeler cotton, and for Sea-Island even more waste is removed. The average production per card was a little more than 70 pounds per day.

Drawing Frames.—The only items which deserve special mention are those which would naturally be noticed by a careful overseer. The trumpets should be especially noticed. If the work has been coarse, the holes in the trumpets will be too large for long-staple cotton, which is always run lighter than ordinary cotton. The writer was once called upon to examine a card-room where there was considerable complaint on account of cut drawing. It was suggested that new trumpets be put in, and soon after everything was satisfactory. As the rollers are farther apart than in coarse work, the clearer waste must be removed much more frequently, or it will

fall down between the rollers and cause bad work.

Twist For Fine Work.—One great trouble many mills have is excessive twist in the roving, especially is this the case on combed work. If we take $1\frac{3}{4}$-inch cotton and card it, the average length of staple is probably about $1\frac{1}{2}$ inch. If it is combed, the average length is not far from $1\frac{3}{4}$ inches, so that although we are putting in the same stock in either case, there is a great deal of difference before we get through. Ordinarily, the twist of roving is 1.2 times the square root of the number. After we reach 1-inch staple, this should be reduced as the length is increased, and in no case should more twist be put in than is absolutely necessary to turn the bobbin in the spinning frame.

Flyers, Traverse and Rollers.—In changing from coarse to fine work it is sometimes found that the noses of the flyers and the fingers of the pressers are too large. When good yarn is wanted these must be changed. Occasionally the front rollers should be disconnected by removing the twist gear, and the nose of each flyer be thoroughly polished with emery cloth while the spindles are running full speed. The top rollers must be more carefully covered than for ordinary work, and the leather must be put on a firmer foundation. As the thread or roving is very small in diameter there must be very little cush-

ion in the roller, or the weight will be taken entirely off the stock. For the same reason, the roving traverse motion should be carefully looked after. It should never be allowed to stand still, and should traverse within $\frac{1}{8}$ inch of the end of the roller. In one case, the writer had a double thread put on the worm which drives this motion, causing the traverse to move twice as fast. The result was so satisfactory that the whole room was changed.

Tension.—The tension is one of the things that needs especial care. The speeder will run if it is too tight, but the result will be disastrous. The cones and cone belts should be well looked after. The writer has known speeders on fine work to run bad for days, when all that was needed was a clean belt. On fine work, the stock is so delicate that very little things often cause a great deal of trouble.

Overseers and Help.—For fine work, every machine needs closer attention than for ordinary work. An overseer who has to look after too many things can not get satisfactory results. He must have leisure in which to watch the work closely, for difficulties frequently arise which require hours and sometimes days to overcome. If the overseer does not have the time to look after the most minute details, there is almost sure to be trouble. Every effort should be made to get and keep good help. There are so many things

which have to be learned in a fine mill which are not learned in other mills, that frequent changing of help is a great misfortune.

Creeling Roving.—Another matter in connection with speeders which often escapes attention is the method of creeling. For fine work, in order to keep the number even, it is necessary to run one large and one small bobbin together. There is a slight difference in the number of roving on a small and large bobbin and a great difference in the amount of tension necessary to turn them. The writer once had some trouble in getting the numbers even on number 100's, and finally changed a pair of speeders to this method of creeling. In a few days it was noticed that these speeders ran better than the others, and all the speeder hands wanted their machines changed also. This has about the same effect as running bobbins from the front and back row of spindles together, as is done in some mills, and is an easier way to accomplish the same result. Another matter which has considerable bearing on the evenness of numbers is to look well after spare roving. The writer once had some 8-hank roving piled on the floor, where it remained several weeks. The overseer afterwards sized it and reported that it was all 11-hank. Investigation showed that the moisture had dried out until the outside layers were three numbers lighter than those underneath. Spare roving should be kept

out of the sunlight, and if practicable, kept in well-covered bins.

Contraction in Twisting.—There is so much more twist in fine work that the contraction is much more than in coarse work. On a mule this is so great that when the spindles are putting in the twist at the head, the rollers are made to deliver several inches of roving to prevent the ends being broken. To a less extent, this is true all through the card- and spinning-room, and when figuring for any desired draft this must be taken into consideration.

Spindle Bands.—In running fine work it is very important to have uniform tension on the bands. If some are looser than others there will be a difference of twist, and consequently of contraction, and this will make a difference in the numbers. This will seem a very trivial matter, but the writer has had trouble along this very line. To test the matter, eight bobbins were put on the spinning frame, and after enough yarn had been spun, it was found to vary entirely too much. After new bands were put on, yarn spun from the same roving was much more satisfactory.

Rings and Traverse.—A mistake which is frequently made is to attempt to spin fine yarn on rings which are too large, or with a long traverse. Several years ago a prominent machine builder advocated large rings and long traverse in such plausible language that many mills were induced

to change their rings to larger ones, frequently with disastrous results. For spinning 80's, a $1\frac{3}{8}''$ ring and $\frac{3}{4}''$ bobbin should be used. It is a very poor place to practice economy by trying to get too much yarn on a bobbin. The speed, too, should be kept within reasonable limits, about 9,000 turns being as fast as is desirable.

One of the features in fine spinning mills which should always be observed is to have everything as clean as possible. The writer, who had been working in a print-cloth mill, well remembers his sensations when first entering a mill for fine yarn. The first thing which claimed his attention was a sign in the picker-room, "One dollar fine for spitting on the floor." He noticed too, that the floor looked as if the notice had had the desired effect. Everything else was in proportion, and the overseer would not hire a girl who came to the mill with a shawl over her head, claiming that any one who was neat about their dress would also be neat about their work. The Clark Thread Company is said to have attractive paintings in the spinning-room, claiming that they have a wholesome effect on the habits of their operatives. Throughout the whole mill the machinery should be frequently cleaned, and this can not be done too often. Of course it is easier to keep a fine mill clean than a coarse one, and it is also more necessary. In many fine mills it is customary to cover the machinery when the

ceiling is swept down, and the pulleys are not brushed out with a broom, but carefully wiped off by hand when the mill is standing.

One of the first essentials in making fine work is to have a competent engineer. A few dollars saved in the equipment of a mill often proves to be expensive economy, and nothing should be left undone that will have a tendency to make better work. Many mill men have become so accustomed to regard a large production as the most desirable achievement in a mill that they are not prepared to make fine work, where quality and not quantity is the great desideratum. A careful engineer knows this, and will lay out his machinery accordingly. Where it is possible, the machinery should be arranged to belt from below, especially in the weave-room. Not only do the belts obstruct the light, but it is impossible to prevent oil from being thrown from the hangers and getting on the cloth. Where goods are worth from 10 to 30 cents a yard, a whole piece being sold as seconds on account of oil stains, occasions a considerable loss. As weave-rooms are nearly always on the first floor, it is possible to put the shafting underneath by having a basement. This will cost something, as the basement will have to be sprinkled, but it will certainly pay in the long run.

In the preceding pages no mention is made of combing, but for numbers finer than 60's the

comber is almost always used. Where extra nice work is required, they are sometimes used on as low as 40's. As their use was somewhat fully discussed in a former chapter, we will not go into it further at this point.

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